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JACK'S

SELF-EDUCATOR

PRINTED IN GREAT BRITAIN

JACK'S SELF-EDUCATOR

A GUIDE TO A LIBERAL EDUCATION

UNDER THE EDITORSHIP OF H. C. O'NEILL

EDITOR OF

"THE PEOPLE'S BOOKS," "THE NEW ENCYCLOPÆDIA," ETC.

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LONDON: T. C. & E. C. JACK, LTD.
35 PATERNOSTER ROW, E.C.; AND EDINBURGH
1916

PREFACE

A DISTINGUISHING feature of the modern world is that the only royal road to success is efficiency. The man who enters the race of life well prepared succeeds: he whose preparation has not been so thorough fails or is compelled to take the second place. Now two things are clear : the only real preparation is knowledge, and many have never had the opportunity to acquire a sufficiently wide knowledge. This book aims at providing this second class of people (which includes the vast majority of mankind) with the means of securing an all-round education. It aims, indeed, at being something of a fireside tutor who will teach an inquirer, quite simply, the outlines of a vast number of subjects, and will, moreover, give him practical help in pursuing his study as his inclination may direct. Anyone who has worked through this book and mastered its contents need feel little fear among almost any class of men. He may feel a reasonable assurance that he has the knowledge which only the most cultivated men possess.

And this suggests another use of the book. Even those who have had the advantages of a public school and university education are ignorant of many things which a really cultivated man should know. If they have taken classics they quite probably know little or nothing of science. If they have devoted their time to science they have shunned the classics. Even if they have graduated with honours in science they may know nothing of the sciences which lie all round those in which they have specialised. For such men this book will provide the opportunity of filling up many spaces in their mental equipment.

Special care has been given to the Courses of Reading. It is hoped that these will be really helpful: not mere catalogues of books, but reasoned and articulated courses such as a tutor might give to his pupils. The courses of reading alone will probably be welcomed by many who know the outlines of a subject but wish to have some specialist direction in pursuing their studies.

THE EDITOR.

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INTRODUCTION

A CHIEF interest of history lies in its imaginative appeal from the present to the past. Consciously or unconsciously in reading it we bring the story of things past to the touchstone of the things that are now. To the average man the selfish element in the study of history is very large, the eager desire to assess the contribution of lives dead and gone to the actuality of his own life now. This being so, it would seem advisable in a limited space to study more at large the things which have most largely and most obviously gone to create our environment, and so in this brief sketch especial attention is given to the history of England and English speaking people. But as national life and movement is vividly affected by the life of larger units it is treated in intimate relation to those larger movements which have affected it. And as any real history must be, in some sense, world history, so too in this study there can be no narrow limitation of time. The long ages in which prehistoric men were striving towards civilization had a very vital part in the making of modern England or America. The confused wanderings of primitive people in times and places remote from us had their share in the making of modern conditions. Only less vital than the tie of nationality is the romantic bond which binds branches of the same race to each other, and no modern historian may neglect the fascinating study of the contribution of the race to the story of the nation. He must bear in mind too the debt of nation to nation and race to race.

History has many sides, as many sides as there are aspects of civilization, and the historian may concern himself with any of these, the history of religion, of art, or of language, but as it was the grouping of men in society which made possible the growth of civilization, so it is primarily with politics in this larger sense that history is concerned.

EARLY MAN AND CIVILIZATION

The beginnings of man upon earth are wrapped in mystery. Modern criticism has shown that the old tradition which represented the first man and woman as living upon earth some 6000 years ago does not tally with the facts as they can be roughly deduced from the findings of modern science. The work of students of palæontology and prehistoric archæology has conclusively shown that for thousands of years, probably for at least a hundred thousand years, there have been men upon the earth, men little better than other animals at first but with an intelligence and potentiality of development which marked them off from these. In colloquial speech a distinction is made between savagery and civilization, but philosophically the savage state is a stage in civilization taken in the larger sense. Ethnologists have tabulated six clearly marked stages in the advance from bestiality to civilization proper. They are the Older, Middle, and Later Periods of Savagery, and the Older, Middle, and Later periods of Barbarism.

The first vital discovery made by men was the use of fire, a discovery like the use of tools and the employment of articulate speech made by man alone of all the animals. The discovery of the use of fire marks the end of the older period of savagery during which the power of articulate speech had also been developed. With the beginning of the Middle Period of Savagery men were now able to include flesh and fish among their foods, whilst before they must have lived on uncooked fruit and vegetables. Previously to this too men probably often slept in trees, for these were safer than the ground, but fire proved a valuable means of scaring away fierce animals by night, and so this habit was abandoned. Men could now leave the tropical regions to which they had probably been hitherto confined and travel into cooler climes, where their energies received more stimulation. The people who had the initiative to do this would advance more rapidly than the others, and hence would arise the differences between savage and civilized races. When the primitive natives of Australia were discovered a few gene-

rations ago they were still at this first stage, knowing the use of fire (as all men have done in historic times), but using the crudest weapons. For the character of the weapons used by men has developed on similar lines as men everywhere advanced in civilization, and some ethnologists mark the periods of development towards civilization by these. Hence we have the Rough Stone Age, the Age of Polished Stone, the Age of Bronze, and the Age of Iron. The great discovery of the use of the bow and arrow marked the Later Period of Savagery.

It was easy now to kill the quickest moving animals. Life became more secure and food and clothing more abundant. Men could now advance into even sub-Arctic regions. But they were still "savages." They rose to the status of "Barbarians" with the invention of pottery, and to a higher form of Barbarism with the domestication of animals in the East and the use of irrigation in the West.

Primitive men seem always to have been moving. Indeed the conditions of their lives would make this necessary. Later, when they began to breed sheep and cattle, they still moved from place to place to find new pasturage. This is known as the nomadic or pastoral stage. But with their arrival at especially fertile lands they sometimes settled down, bred fewer sheep, and used the land to grow more things. This is known as the agricultural stage. Life became then more complex, man's needs greater, and it was found easier to supply them by specialization of work and division of labour. The use of the camel and the horse made commerce possible. Cereals were carried from farther Asia and cultivated in the lands round the Mediterranean, and with this new source of food supply it became possible for large bodies of men to settle down in fairly elaborately organized political communities. In all such early communities there were a ruling class and a slave class, and at the head of all a king. To this period too belongs that most momentous development, the acquisition of private property, for previously all possessions had been communal.

The highest stage of Barbarism was reached when men discovered the art of smelting iron, an art which was to facilitate immensely the coming of civilization. It was the first new art not concerned primarily with the improvement of the food supply, though incidentally it served this purpose too. It helped man in the making of more powerful weapons to fight against beasts and other men and to work on other materials, such as wood and stone, for the building of houses and roads and walls. It helped too towards man's æsthetic satisfaction, which hitherto had been fed by drawings scratched on bone or ivory, or figures moulded from rough clay.

And now man was on the very brink of civilization in the narrower sense, the first stage of which is generally taken to coincide with the invention of writing, by which men could communicate their highest and best thoughts to their contemporaries, and one generation could hand on to another the record of its story. The first writing was of course hieroglyphic, but it was the symbolizing of events and the expression of ideas by the use of graphic signs which marked the transition from barbarism to civilization. The subsequent invention and general adoption of the Phœnician alphabet was but a minor change. It was then by these and numerous lesser inventions and discoveries that man reached the threshold of history proper.

Since then he has advanced wonderfully and subtly, but with Lewis H. Morgan, the great ethnologist, we may admit that the achievements of man in his barbaric days transcend, in relative importance, all his subsequent works.

The Egyptians.—The first records of continuous civilizations are of the Egyptians in the Valley of the Nile and the Akkadians or Sumerians round the Euphrates, for it was in the neighbourhood of great rivers like these that lasting communities first grew up. When both these peoples began to make records about 4000 years B.C. they were already highly civilized. The Egyptians belonged to the Hamitic race, the brown or red-brown, or yellow-skinned people, who inhabited the sub-tropical regions of the Eastern Hemisphere. In the hottest parts of that Hemisphere the people were black-skinned and black-haired and are called negroes, while the people who had spread over Europe and Asia have been called Mongolians, and to these the Akkadians belonged. It was after the establishment of the two great early civilizations that two new groups of people broke over Europe and Western Asia. They were both sometimes called Caucasian because they were, at one time, erroneously supposed to have come out of the region round the Caucasian mountains to the east of the Black Sea. One group is distinguished as Semitic, while the other is sometimes called Japhetic, both names taken like Hamitic, from the sons of Noah. The Japhetic group is better known as the Indo-European because it conquered India and Europe, and more commonly still, if less correctly, Aryan, because the Aryans were the first branch of the race to write down their records.

The Semites seem really to have had their origin in Arabia whence they spread over Western Asia, acting and reacting on the civilizations of both the Nile and Euphrates Valleys. The Aryans, on the other hand, did not touch on these for a long time, but great waves descended about 3000 years B.C. through Afghanistan into India, while others spread over Europe in successive inundations, the Celtic which rolled steadily forward into the British Isles and southward into Spain, the Hellenic and Italian which bore down upon the Greek and Italian peninsulas between 1500 and 1000 B.C. and rapidly became highly civilized peoples, the ruder Teutons who

spread over Germany and Scandinavia, and the Slavs who in the end won most of Eastern Europe for themselves.

The civilization of the Aryans, the great root stock of the nations of the West, must have a more compelling interest than those of ancient Egypt or Mesopotamia, as the land between the Tigris and Euphrates was called, but these for their antiquity and the debt which succeeding civilizations owe them are full of fascination too. Until half a century ago all knowledge about these ancient civilizations depended on the references to them in the Bible or on writings later than 500 B.C., but recently excavations of their sites on a vast scale have revealed in intimate detail the story of their development, confirming wonderfully the accuracy of the old authorities. The chief of these old authorities on the history of Egypt were Herodotus the Greek historian, who wrote in the fifth century B.C., and Manetho, an Egyptian, who at a somewhat later date based his account on the records of the Egyptain priests. The Egyptians measured time by their dynasties, of which the twenty-sixth ended with King Psammetichus in 664 B.C. The first ten dynasties are known as the Old Empire, the next seven as the Middle Empire, and the remainder as well as the last kings who are not reckoned as a dynasty belong to the New Empire. The eighteenth dynasty begins about 1580 B.C., a time which marks the driving out of a foreign race of kings, probably a Semitic dynasty under whose sway the Israelites had flourished in Egypt. The restoration of an Egyptain race of kings who "knew not Joseph" led to that policy of oppression which was successful in driving the Semites altogether out of Egypt.

It was the kings of the third and fourth dynasties who built the Pyramids at some time between 4000 and 3000 B.C. The Egyptians must at this time have had control over a vast amount of labour—slave labour—as in all ancient states. The evidence show too that they must have used metal tools, and they must have had a highly developed science of mathematics. But long before this age of the Pyramids the Egyptians were well on the way to civilization. Associated with the tombs of their kings are found stone tools of an advanced type.

The Civilization of Babylon.—It was probably about the year 1800 B.C. that the Semites of Arabia invaded Egypt, but long before this Semitic waves had flowed from that centre into Mesopotamia, so that the earliest records, at least as old as those of the Egyptian dynasties, show us a new Semitic and conquering race side by side with the Sumerian population.

Already the Sumerians were a civilized people and could write, for the "cuneiform" or arrow-shaped writing in which later the story of Assyria and Babylon was written was Sumerian in origin. The Semites, a more vigorous but less cultivated race, were probably quick to absorb the existing civilization.

About 2000 B.C. a second great Semitic wave rolled out of Arabia over Mesopotamia, and it was from this stock that Abraham, the father of the Hebrew people, came from Ur of the Chaldees into the land of Canaan. The Semitic invasion of Egypt was apparently part of the same movement. After this time communication between the two great centres became more frequent. The Egyptian civilization had developed quite independently, but as time went on the Babylonian culture dominated it, and in the second millennium B.C. the cuneiform writing and the language of Babylon had become the language of communication between the two centres and the lesser kingdoms neighbouring on Babylon.

Babylonia is the south-eastern part of Mesopotamia. The north-eastern part is Assyria, taking its name from its centre at Asshur, and also subdued by Semites. To the east of Assyria lay the non-Semitic kingdom of Elam. Shortly before Abraham went out from Ur to Canaan, Babylonia had dominated both of these under the first king of the "First Babylonian Dynasty," Sumu-abu. Fifth after him was Hammurabi, whose famous "Code" of laws is one of the landmarks of history. From it we glean what was the character of Babylonian civilization and the organization of its society with its three classes of nobles, freemen, and slaves. It shows that the civilization was of a very high type and the system of government extremely elaborate.

After the death of Hammurabi new kingdoms were set up in the neighbourhood of Babylonia and new peoples attacked Babylon. To the north of the Persian Gulf there arose a new "Kingdom of the Sea." The Hittites, a non-Semitic and non-Aryan people probably from Asia Minor, raided but did not conquer. Their attacks prepared the way for a real conquest by the Kassites, a barbarian people to the East. They succumbed to the Babylonian civilization. Soon afterwards a new Semitic invasion increased the importance of Assyria.

The eighteenth dynasty was now ruling in Egypt, and its history finds unique illustration in a great collection of tablets (discovered in 1888) known as the Tell-el-Amarna letters. They are letters to two Egypytian kings from the various rulers of these kingdoms of the East, the Kassite King of Babylon, the King of Assyria, two kings of Hittite kingdoms and others. This was just after the days of the great Egyptian King, Thotmes III, who had conquered Assyria. His successors gradually lost his conquests and Egypt fell back in the race for power. The Tell-el-Amarna letters show that at the end of the fifteenth century B.C. they had begun the policy of paying money to hostile peoples to avoid war. The documents are begging letters asking for more.

Decline of Egypt.—The great days of Egypt in Asia were over, but the period of decline is illuminated by the name of Amenhotep IV, or Akhenaten, who tried to turn the Egyptian worship of the Sun into a true adoration of One God, taking the Sun as His symbol. He was a voice calling in the wilderness, and after his death the old Egyptian orthodoxy prevailed.

The kings of the nineteenth dynasty, the Ramesides, were great builders, and through this much of the achievement of their predecessors was later attributed to them. By this time the Jews had long been established in Palestine, and while the twentieth Egyptian dynasty was reigning the Hebrew kingdom was set up under Saul and David. The Philistines, the conquest of whom plays so large a part in the story of that kingdom, were a people from Crete who had settled to the south of Palestine. After the death of Solomon, the third king, the Hebrew kingdom broke up into two unimportant principalities held in tribute successively by the greater kingdoms near.

It was not long before Egypt likewise broke up into minor states (between 930 and 730). Meanwhile, ever since the days of the Tell-el-Amarna letters, Assyria had been growing in strength and she soon engaged in a struggle with the Kassite dynasty of Babylon. The dynasty was overthrown, but a genuine Babylonian dynasty took its place, and for a while Babylonia recovered something of its former greatness, but not for long. For many years Assyria and Elam struggled for sway in Babylonia, but Assyria was generally the dominant power. During the eleventh and tenth centuries B.C. the Syrian region was left almost entirely without interference.

The Jews.—It was during this time that the Hebrew kingdoms rose and decayed and that the Phœnician city states formed by a group of the Canaanite Semites developed their enterprise by sea. During much of this time Assyria suffered eclipse, the Aramæan Semites honeycombing their empire, but in the second half of the ninth century B.C. there was a revival, and in the second half of the eighth century Assyria had become once more an aggressive and conquering state, and in the end got direct rule over Babylonia and constantly harassed the Jews, Phœnicians, and Egyptians. The last great King of Assyria was Ashurbanipal, an indefatigable collector of records, which remain as our chief authority on Assyrian history. After his death in 630 B.C. Assyria again declined. Egypt had thrown off its yoke and now there was a revival in Babylon under the Chaldean King Nabopolassar. The Chaldeans were a Semitic people in the extreme south of Mesopotamia. Later the names Chaldeans and Babylonians were used interchangeably. The son of Nabopolassar was the Nebuchadrezzar whom we read of in the Bible and who in his conquering course carried the Jews off to their "Babylonian captivity."

Nebuchadrezzar's name has been remembered too as the names of mighty builders always are. It was under him that the famous "hanging gardens" of Babylon were constructed. But before the end of the sixth century B.C. the Chaldean and Lydian empires and Egypt were all conquered by the power of Persia, which then threatened the lands farther west. The Lydian state west of a line from the middle of the south of the Black Sea to the north-east corner of the Mediterranean had been conquered by the Dorian Greeks long before this. The Persians were a people who together with the Medes, another Aryan branch, possessed the lands east of Mesopotamia. They had been there for a period of unknown length, and always it was the Medes who had predominated, but under the great soldier Cyrus, who in the middle of the sixth century seized the Median throne, the triumph of the Persians began.

It was he who conquered Lydia and Babylonia; it was left to his son, Cambyses, to annex Egypt. The next obvious place to attack was Asia Minor, but Babylonia had never been really able to hold that district, and here the power of Persia was to receive its first check.

Prehistoric Greece.—Asia Minor had become largely the heritage of the Greeks or Hellenes, an Aryan people who by the middle of the second millennium B.C. had won for themselves Greece and the islands of the Ægean Sea, and were settling on the coasts of Asia Minor before the end of it, and even founding dynasties in states existing inland in Asia Minor as the Dorians did in Lydia.

The Dorians were the latest comers of the three divisions of the Hellenes. The others were the Æolians and the Ionians whose settlements in Asia Minor were to the north of the Dorians. In Greece proper the Dorians secured the western half of the Peninsula, the whole of the Peloponnesus, and some of the islands. The earliest record of Greek history is found in the Homeric poems written about 800 B.C. and now no longer romantically ascribed to the blind poet Homer, but generally regarded as a cycle based on ballad poetry of a much earlier time. In them the Greeks are not spoken of as Hellenes distinguished as Dorians, Æolians, and Ionians, the names familiar in the historical period proper of Greece, but as Achæans, Argives, and Danai. In the Homeric poems Bœotia, a part of Greece not distinguished but rather discredited in the historical period, is the practical centre of Hellas, while Mycenæ is its political centre. The Homeric poems tell of the wars of the Greeks under their leader the King of Mycenæ against Troy in Asia Minor.

Excavations at Troy and Mycenæ both have gone to suggest that there is a sound historical

basis for these mythical stories of ancient heroism. Excavations at Crete and Mycenæ have revealed an advanced civilization which must go back to the third millennium B.C., and there is question as to whether the civilizations known as the Nimoan and Mycenæan were Hellenic. As yet there has been no success in deciphering the scripts found, which would seem to be a fairly easy task if the language were Hellenic. The religion, too, is singularly different from the religions of the Greeks in the historical period. On the other hand a distinctly Greek spirit is present in the art of these civilizations, which most scholars assumed to be connected with each other.

The Greek City State.—But these things were far past when Greece clashed arms with Persia. As long as anything is known of the Greeks they were a highly civilized people living in cities with kings at their heads, with a select council to advise the king, and an assembly of freemen, in fact with the germs of many forms of government.

In this did Greece differ from the empires of the East, which were all despotisms of the most uncompromising type. When the Persians, Aryans though they were, conquered Babylon, they continued inevitably this mode of government. Under it the people counted nothing at all politically.

The city state was the characteristic political development of the Greeks. It was alike their strength and their weakness, for while through it intense and vivid patriotisms and civilizations came into being, it prevented any political union or national enterprise. Thus while the Greeks could unite for worship, as when they thronged to favourite shrines like that of the Delphic Apollo, or sent representatives to compete in the Olympic games, there was never any question of a political union of all Greece. By the time that Greece had to face Persia in arms two main types of city states divided Greece, aristocracies and democracies. Both had been developed through two previous stages, when the kings were replaced by oligarchies and these again by tyrants, a name bearing no sinister taint to the Greeks but representing the Roman "Dictator."

Of the two greatest city states in Greece in the fifth century the Dorian Sparta was a typical aristocracy of the most rigid type, the Ionian Athens a democracy with all the glorious possibilities and insidious dangers which beset that form of government. In Sparta life was circumscribed by militarism. The state and the state's safety were the supreme ends. All boys were brought up by the state from the age of seven years, and Spartan discipline has become a proverb. In Athens it was the individual who mattered, and no bounds were set to the development of the democratic principle. While Sparta bred only soldiers, Athens bred artists, poets, and philosophers. But always it must be remembered that here, as in all ancient states, there was a basis of slave labour which made more easily possible alike the efficiency of Sparta and the vivid individualism of Athens. The details of later Greek history are apt to be blurred in an impression of the rivalry and clashing of the two types sublimated by these states, and the impression is accurate enough.

THE CLASSIC PERIOD

With the beginning of the fifth century B.C. the centre of the world's civilization moves westward at first to Greece, whence it was to advance still westward with the growth of Rome's power until the classic tradition embraced all the Mediterranean states. The classicism, which was of the essence of the Greek and Roman civilizations, is an individual thing, different from the colossal but crude grandeur of the eastern civilizations, different too from the romanticism of the Middle Ages and modern times, though it contributed so much to these.

The well-spring of the classic tradition is Athens, and it was that state which alike developed and defended it against the power which threatened to crush it in the buoyancy of its youth. If Persia had prevailed against Greece the whole course of the world's history would have been changed. It would have meant the stamping out of the great root ideas of western civilization, those ideas whose working out has made the wonder and perplexity of history in the West ever since, and which are, even now, leavening the immobility of the East.

In the year 500 B.C. it seemed that the Persians, having conquered all western Asia, must inevitably extend their conquests to Europe. Some of the Greek cities rose about this time in revolt against the Persian satrap, who represented the power of the "great king" in that district. They appealed to the Greeks over sea to go to their help and the Athenians sent some ships, but it was a forlorn hope, and they were recalled, and before long the rebellion was stamped out. Persia's policy of aggression now coincided with a policy of revenge. It was, however, ten years before King Darius sent a large army to attack the Greeks. The defence of Greece was left to the Athenians with the help only of the friendly little city of Platæa. The Spartans delayed because of the alleged reason of a sacred feast whose observance nothing must interrupt, but there was probably the added motive of unwillingness to co-operate with Athens. The first act in the great struggle ended with the brilliant Athenian victory on the plain of Marathon.

The Struggle between Greece and Persia.—It was again ten years before Xerxes, the son of Darius, sent a vast army for the Great Invasion

of Greece, in which no lavishness of men and money was spared. The largest army that had ever been seen crossed the Hellespont on a bridge of boats specially built for it.

It was an army garnered from the conquered peoples of Asia, and had no great heart for the fight, but the Persians ever put their trust in numbers and brute force, and those who were reluctant were spurred on by the sight of the quartered bodies of malingerers hung along the line of way.

Such was the material with which Persia proposed to crush the Greeks with their vivid individualism and love of freedom. The idea of defending Thessaly was abandoned, but the Spartans tried to hold the pass of Thermopylæ, the last defence of the Peninsula before the Isthmus of Corinth. When Leonidas, the Spartan king, found that there was another pass by which the Persians could get round to his rear, he had not sufficient men to guard it. He refused, however, to abandon the pass he was already defending, and when at last two hostile armies hemmed him in he and his little band fought their way out at the north end of the pass and there fought to the finish, suffering a defeat more glorious than any victory.

Greece now lay open to the Persians as far as the Isthmus of Corinth, but the fight at Thermopylæ had weakened the confidence of the invaders. Athens was sacked, but its people had taken refuge on the fleet. The building of a great fleet by Athens had been the policy of the Athenian Themistocles, who now vindicated it by the great victory of Salamis over the Persian fleet, which was as unwieldy and inefficient as its army.

The destruction of the Persian fleet made the commandeering of the giant army impossible. The bulk of it retreated ere it should be cut off. The remnant, three thousand of the best soldiers, were routed the next year at Platæa, and so Greece, and through her all Europe, was saved from the aggression of the East.

Curiously enough on the day of Salamis another people of eastern origin received a decisive defeat at the hands of the Sicilian Greeks, for in Sicily and South Italy by way of colonization a new Greece had grown up reproducing the society and organization of the mother country. The victory of Himera by the Sicilian Greeks over Carthage, the great maritime colony set up long ago on the north coast of Africa by Phœnicia in the days of her greatness, emphasizes the results of Marathon, Thermopylæ, Salamis, and Platæa.

The Age of Pericles.—The results to Greece of the glow of conquest may be seen in an increased ardour of patriotism everywhere which unfortunately was local rather than Greek, and, indeed, intensified rivalries rather than reconciled them. The effects of this new joy and patriotism may be seen best in the marvellous development of Athenian civilization at this period. It is famous in history as the "Age of Pericles," from the name of the great statesman who was chosen by the democracy to rule Athens in 460 B.C. and kept that rule to 429 B.C.

It was during this period that the art and literature of Athens, the standard of classic culture, arrived at their best. The age of Pericles was the age of Æschylus, Sophocles, and Euripides. Aristophanes, the first great Athenian comedian, began to write at its close. It was the age, too, of the greatest of all Greek sculptors, Phidias, who with his pupils ornamented the marvellous buildings in which the triumphant exultation of the Athenian democracy found expression.

Paradoxical at it sounds, Athens at this time was really an aristocracy drawing tribute from an Empire. This was the League of Delos, in which the maritime states of Greece bound themselves together on the defensive against Persia. At first on equal terms with Athens, and having their treasure at Delos, the island sacred to Apollo, the states soon became mere tributaries of Athens, and the treasure removed to that city was used largely for its embellishment, and for the enlargement of the lives of the Athenian citizens.

One main result of this policy was to foment the jealousy of the states outside the league and discontent within. The result of these accumulated jealousies was the Peloponnesian War in which nearly all the Greek states of the mainland joined under Sparta, the traditional rival of Athens, to attack her. For nearly thirty years, from 431 to 404 B.C., the Peloponnesian War dragged on. Athens made at first a brilliant defence. Forced though they were to abandon the open country, her citizens entrenched themselves between the famous Long Walls which joined the city to the sea at her port of the Piræus. A terrible outbreak of the plague in 430 under these conditions was a national misfortune and was soon followed by the death of Pericles.

The Athenians were impregnable behind their Long Walls, and there was a constant food supply by sea, but the fight was unequal, and when her navy failed her the struggle could only end in one way. By the famous Sicilian Expedition in 415, which the Athenians sent against Syracuse, and which ended in terrible disaster, Athens lost a large army and a flee At last in 404, after the Spartan comma Lysander had captured another large fleet, city was blockaded. Athens had to give up her fleet, ignominiously to demolish her fortifications to the sound of Spartan songs of rejoicing and accept the oligarchic government which Sparta, according to her traditional policy, forced upon her. Within a year the democracy was restored, but Athens' greatness was a thing

of the past. Only its glamour remained, a glamour which later dazzled all-conquering Rome and led her to submission in the midst of victory.

Yet the stream of culture ran still clear in Athens. Socrates, her first great philosopher, was still teaching at the end of the Peloponnesian War. Plato, his young friend and admirer, was teaching and writing all through the first half of the fourth century, and the activity of Aristotle, in his turn the pupil and friend of Plato, lasted on till nearly the end of the third quarter of that century. But politically Athens was dead.

In the full flush of conquest the Spartans had attempted to found an empire in their turn, but Sparta had no genius for sea power, and her fleet was destroyed in an expedition against Persia. Her ambitions were now limited to a supremacy in Greece itself, which was however short-lived. Her power was overthrown by Thebes, who in her turn and through the genius of one citizen, Epaminondas, established a short-lived supremacy. It died with the death of Epaminondas and the next great power in Greece came from without.

This was Macedon, a state bordering on Greece to the north. The Macedonians, though the Greeks despised them as "barbarians," were largely Hellenic in origin, and though they had not developed a culture such as Greece had known they were a people of great ability, and the "barbarism" which the Greeks despised spelt strength in conflict.

It was just after the death of Epaminondas, when the leadership in Greece was going begging, that Macedon fell under the rule of Philip, a man of great ability, a statesman and a general and, above all, a Phil-Hellene anxious to claim for Macedonia its Greek heritage. He proposed at first a union of Greek states against Persia, and was nominated general-in-chief. Athens, recovered to some degree of prosperity, opposed Philip, stung to resentment by the Philippics of the last notable statesman begot by Athens, Demosthenes.

Demosthenes saw that Philip aimed at Empire, and led a party in Greece against him. Its defeat made that empire more certain, but in the moment of victory Philip was slain by an assassin in 336 B.C.

Alexander the Great.—His son Alexander, one of the world's greatest men, inevitably seized his heritage, and his predominance in Greece became the basis for that meteoric career of conquest which makes the story of Alexander the Great read as some fairy tale, rather than sober history. Within ten years he had conquered the whole of the Persian Empire and dotted it over with outposts of Greek civilization. He had led an army into India and conquered the Punjab, whence he returned to Asia only because of the mutiny of his soldiers aghast at their distance from home. He died an untimely death at Babylon in 323 B.C., when he was only thirty-three years old.

Alexander was not only an incomparable soldier and general, but he was a great statesman too. The keynote of his policy was the fusion of East and West, and though this even to-day seems an impossible ideal it did meet with some measure of success. A leaven of Greek culture was introduced into the conquered regions, and when the empire inevitably broke up after Alexander's death the new kingdoms were for the most part ruled by his generals, and though these rulers and their successors became orientalized in time it was not before some slight savour of classicism had been imparted to their dominions.

The dynasty of the Ptolemies in Egypt was Greek, and Alexandria was long the leading centre of Greek learning. The Greek dynasty of the Seleucidæ won Syria for themselves, and it was thus that the New Testament came to be written in Syriac Greek. The greater part of Asia Minor broke up into small kingdoms. Macedonia itself was subject to a rapid succession of rulers, but each kept a tight grip on Greece through the despots set up to rule the several cities.

And now at last there appeared in Greece that ability to unite for patriotic defence which had been absent so long, but it was among the lesser states.

Various leagues or federations were sucessively formed with the object of throwing off the yoke of Macedon. They met with some measure of success. Yet again the old spirit prevailed and a rivalry broke out between the two chief leagues, the Achæan and the Ætolian, and Sparta temporarily reviving under its King Cleomenes. But all these minor ambitions were to yield before a mightier conqueror than any Macedonian. The great and growing power of Rome which was to sway the destinies of the world for centuries to come absorbed Greece in its onward march.

The Rise of Rome.—Rome was a city of Latins, one of the two Aryan branches which had pushed their way into the Italian peninsula about the same time, or perhaps rather later, than the Hellenes were taking possession of Greece. The other branch were the Oscans or Sabellians. The land west of the Tiber was occupied by the Etruscans, a pre-Aryan people probably akin to the pre-Hellenic population of Greece, but more strongly entrenched than these, so that the Latins contented themselves with the low lands to the east of the Tiber, which thus became Latium, while the Sabellians took the higher lands east and the land to the south of Latium.

The city states which grew up rather later

than in Greece were of the same type. There were always the king, an aristocracy, a free population, and a slave class. Very early too the Latins joined, like the Greeks, in some sort of loose federations for mutual defence. But what no Greek city had managed to do Rome did. Athens had never been able to impose her empire in such a way as to establish a feeling of solidarity. This was the genius of Rome, for only so and partially by this word genius can the spectacle be explained of this one city, favourably situated no doubt, extending its sway until Rome becomes coterminous with Italy and the Roman Empire coterminous with the greater part of the known world.

According to tradition Rome was founded in the year 753 B.C. by Romulus. The story is wrapped round with mythical detail, but out of it all emerges the fact that the city on the Tiber, originally a border fortress of the Latins, was a stronghold coveted by Etruscans, Latins, and Sabellians alike, and that elements of all three mingled with its population. For many years Rome was ruled by kings, at first, like all early kings, war leaders made permanent, and then finally becoming hereditary monarchs. At last, in 509 B.C., according to the tradition, kingship was abolished by the normal process in ancient city states. The last dynasty which came to an end by the expulsion of "Tarquin the Proud" was Etruscan, but the motive of the revolution was not wholly racial, for the Etruscan nobles in Rome took their part in it with the rest.

To avoid the danger of tyranny the kingly power was delegated to two "Consuls," and henceforth the republic in setting up a new office filled it always with two magistrates. For some years after this revolution Rome was under a cloud. She was threatened by a friendship between the Etruscans and Carthage, but within thirty years Carthage received a check by her defeat at Himera, and the Sicilian Greeks were successful in a struggle with the Etruscans.

From this dates the decline of this mysterious people with their language still unreadable by scholars, with their love of colour and mixture of contemptuous cruelty towards, and cynical exploitations of a conquered enemy. These qualities of the Etruscan have left their mark on the ballad literature of ancient Rome which relates to the oppression of the Tarquins. It has been supposed that they were related to the Philistines, and their spirit has in it much of what is proverbially described as Philistine, a spirit manifest too in the history of Rome and perhaps due to the Etruscan blood in its people.

The revolution which established the republic had probably for cause and certainly for effect an expansive movement in the internal and external history of Rome. It was not long before she re-established her supremacy in the Latin League which she had lost as an immediate effect of her revolution. She was constantly engaged in a struggle with the Sabellian peoples to the east and south, and soon again too with Etruria reviving after her check.

In all these contests Rome was more or less successful. It is the beginning of her heroic time and legend hangs about it. Coriolanus, who fought for and then betrayed and at last saved his country with the loss of his own life, is a typical figure, or Camillus, who took the Etruscan city of Veii after a prodigious siege. At the beginning of the fourth century a new enemy poured over the Alps into Italy, overwhelming the Etruscans irretrievably and sacking Rome in 390 B.C., putting the city to flames. These were the Galli or Gauls, a branch of that Celtic people which had long had its centre north of the Alps stretching along the Danube Valley. They did not stay in Latium, but established a "Cisalpine Gaul" in the valley of the Po.

The Etruscans were ruined, but Rome's rapid recovery gives proof of her vitality. She continued her conquering course, and in the year 381 B.C., by the admission of the citizens of the conquered Latin city of Tusculum to the full rights of Roman citizenship, she began a policy which in time as it were spread tendrils from the heart of Rome through Italy and later through the Roman Empire.

Meanwhile great changes were taking place in the constitution of the government and society of the republic. Already before the expulsion of the kings the plebeians had the right of meeting in the Comitia Centuriata, but this was chiefly for military purposes. The power of electing the magistrates was given to the Comitia Centuriata when the republic was established, but at first they could only elect patricians to the magistracies.

By degrees the social and political grievances of the plebeians led them to threaten to secede from the state altogether, and the result was a succession of laws which gradually put the wealthier plebeians on the same social footing as the patricians. For the future one consul had to be a plebeian, and at length inter-marriage between patrician and plebeian was recognized. The creation of the Tribunate of the Plebs with a power of vetoing the acts of the magistrates or senate, if these were in any way obnoxious to the Plebs, gave political power to the lesser plebeians. As time went on and the plebeians grew more numerous and powerful their officers and assembly of tribes got the right to pass laws binding on the whole state. The condition of the poorer plebeians was improved too by restrictions on the monopoly by the patricians of the common lands taken from captive states, by the insistence that great landowners should employ paid as well as slave labour, and, above all, by the planting out of yeomen as military colonists in conquered territories.

In this way this crisis in Rome's development was manipulated and she was the freer to pursue her conquests.

The Latin League, resentful of Rome's supremacy, took arms but was defeated. Its states became subject to Rome with the full rights of Roman citizenship.

Not all the conquered cities received the fulness of these privileges. The Etruscan city of Cære was the first to receive the modified rights of citizenship, the political vote being reserved. This form of citizenship, called afterwards "Italian," was largely extended. This policy was soon to justify itself in the loyalty of the Latins and Campanians when the Greek cities of South Italy, helped by the Samnites, took up arms against Rome. For some years Rome had acted as mediator between these states, but her interference was resented, and in 280 the help of Pyrrhus, King of Epirus, was enlisted, and at first Rome met defeat at his hands. But the "Pyrrhic" victories were fruitless, and were followed in the end by defeat, and the brilliant but ineffective Greek withdrew, leaving the south of Italy open for a complete conquest by Rome, who was now mistress of all Italy.

Now for the first time after the defeat of Pyrrhus at Beneventum in 275 B.C. the kingdoms of the East began to realize that a great new power had grown up in the West, and Ptolemy, King of Egypt, sent an embassy to Rome. Immediately too Rome had to measure swords with Carthage, her only possible rival in the West.

The Duel between Rome and Carthage.—The Carthaginians had had a great past and it seemed that they might yet have a great future. There seemed no reason why Rome rather than Carthage should become mistress of the West. Carthage was dowered with the Phœnician genius for seamanship; Rome as yet knew nothing of ships. But Rome was full of vitality while Carthage was really in decay. Her narrow oligarchy erred always on the side of caution, and though dying Carthage could produce great heroes and even able statesmen these were always hampered by the government.

It was by taking sides in quarrels between Sicilian cities that the two powers first came into conflict; but consciously or unconsciously the duel was fought for supremacy in Sicily and ultimately over the Mediterranean world.

During the first Punic War Rome proved the need of a navy and forthwith supplied the want, but because they knew that seamanship must be a question of years and experience they determined to make their sea fights as like as possible to land battles, and so supplied their vessels with grappling irons which held fast the enemy's ships while the soldiers fought hand to hand.

The inexperience of ships led to much wreckage and disaster, and it was impossible to storm Carthage itself, but the Romans held on, and at the end of the war Sicily at least was theirs. One brilliant general the Carthaginians had had, Hamilcar Barca by name. With the patience of fanaticism he began to build up an elaborate plan of revenge. He asked permission of his government to retire to Spain, where Carthage had many colonies, and with a sense of relief they consented. There he spent his life, extending the power of Carthage over the native tribes thus to provide a basis for his attack on Rome. He died leaving a heritage of revenge to his sons, the famous Hannibal and his brother Hasdrubal.

Hannibal, one of the most brilliant soldiers of history, made his famous passage of the Alps in mid-winter of the year 218. So began the second Punic War which ended only in 201. Hannibal won brilliant victories but got no support from home, and was thrown on the defensive, while the brilliant young Roman general Scipio by his fighting in Spain cut off the base of supplies.

When Hasdrubal at last got away to help his brother in Italy in 207 his army was defeated and he himself killed. The first intimation Hannibal received was Hasdrubal's head thrown into his camp, for the Romans were ruthless in war. His hopes were now killed, and in 202, after sixteen years on Roman soil, he was recalled to Carthage in the forlorn hope of defending the city against Scipio, now attacking the Carthaginians at home.

The war ended with the complete submission of Carthage. She became a "Socius" of Rome, like the Italian Socii managing her own affairs, but subject to Rome on questions of war and peace. Hannibal bravely tried to reorganize the internal affairs of the city, but was driven forth by jealousies within a few years.

From this date there are two currents in the history of Rome. There is a continual stream of conquest, a tale of unbroken success; and there is an internal history chequered and bloodstained, a story of experiment and readjustment.

The Roman Empire and Revolution.—After the war with Carthage Rome was really in need of rest, but no pause occurred, and this fact gives the key to this double story of success and disaster. The Roman Empire grew too fast for the government to cope adequately with the problems of its administration. There is much misery and sordidness through the need of readjustment in society and politics, yet this is but a background for a marvellous development of civilization, a cosmopolitanism whose subtlety and variety have never been surpassed.

Between 200 and 136 B.C. Rome conquered first Macedon, meaning genuinely to protect Greece, having fallen under her spell, but in the end inevitably annexing Greece too. The conquest of Italy as far as the Alps was com-

pleted. Two flourishing provinces were set up in Spain, one in the basin of the Ebro and one in the valleys of the Guadiana and the Guadalquivir, and from here Rome gradually extended her sway over the greater part of the peninsula, permanently Latinizing its language and civilization in spite of sharp struggles with its barbaric but fine population.

To maintain land communication with Spain alliance was made with the old Greek colony, Massilia (now Marseilles), and beginning by fights with the savage mountain tribes near, conquest was gradually made of the Lower Rhine Valley, a starting-point in the conquest of Gaul (now France).

Meanwhile Carthage had risen in rebellion, stung beyond endurance by Rome's refusal to allow her to defend herself against the Numidians, who were raiding her territory. The third Punic War and the famous siege of Carthage ended with the levelling of the city to the ground in 146 B.C., and her dominions became a Roman province.

In 136 B.C. Attalus, King of Pegamun, left his kingdom to Rome by will, and thus she acquired her first foothold in Asia Minor.

Meanwhile already the want of readjustment was manifest, and the year 133 B.C. began a period of revolution. The senate, which inevitably with continual warfare and need of prompt action had absorbed practically all political power in the state, was itself fast becoming degenerate. Many of the best noble houses had been wiped out in the wars and new men had taken their place.

The new provinces were taxed and their treasure poured into Rome, breeding a spirit of luxury and love of ease. The provinces were governed by pro-consuls and pro-prætors, men who had already served in office and were given this extension as a sort of prize.

The taxes were farmed out, and the "Publicani" who farmed them could grind the subject-peoples at their will, and return only a fixed sum. Corruption among all classes of officials in the provinces was the natural result of the system.

Meanwhile in Italy agriculture declined. Swarms of men who had served in the army were turned loose upon the land on their discharge, and inevitably went to swell the rabble population of Rome. The slaves everywhere were still ground down, and they and the gladiators, often captives of war made slaves, chosen for their great strength and pent up in their prison schools, formed an especially dangerous element in Roman society.

The new Greek learning imparted by slaves, and often warped to mean licentiousness, helped in the destruction of the old Roman sobriety of manners and purity of morals.

It was two noble brothers, Romans brought up by a noble mother in the old Roman discipline, who first tried to cope with all these evils and lost their lives in the attempt. Tiberius and Gaius Gracchus strove with the conviction of idealists to reform the Roman government. Tiberius, the elder by nine years, was little more than an idealist. He got a bill passed by which the monopoly by the senatorial class of public lands (largely lands taken from conquered states) was ended, and such land was let out to the people. It has been described as a small holdings bill. Tiberius was so anxious for its success that he strove to override the laws of the constitution. He was assassinated, but his brother Gaius Gracchus took up the work of reform. He was a practical man as well as an idealist, but in the end he too had himself killed by a slave to save himself from being assassinated. One good thing he had achieved—the adequate trial of provincial governors accused of extortion, and this by men of the "Equites" or rich business class. Unhappily this method made a rift between the two upper classes of Roman society. It was Gaius Gracchus who began too that policy of corn doles to the Roman populace which degenerated into a wholesale system of bribery till the mob called for free bread and free games as their right.

But above all the work of the Gracchi was to discredit the senatorial government so inadequate to its task. Its inefficiency was seen in a few years in the long struggle with Numidia, which defied Rome largely through its confidence in a system of bribing the Roman envoys.

Two great soldiers, Gaius Marius, an Italian, and a "new man," and Lucius Cornelius Sulla, a member of a Roman patrician family with all the vices of his class hardly redeemed by the brilliance of his generalship and the perfection of his culture, stand out at this time.

It was with men like these that the chance to sway Rome's fortunes now lay. At this moment a new enemy threatened Rome, the Germans, who were in the forefront of those "barbarian" nations who were already advancing from the North, and whose movements form so large a part in the later story of the Roman Empire. In Southern Gaul Marius defeated them, beating them back so decisively that some centuries passed before they attempted again to violate the Empire.

In the year 91 B.C. the "Social War" broke out, in which the Italian allies demanded, and for the most part won, the privileges of Roman citizenship. Mithridates, King of Pontus, seized the opportunity to attack Rome in Asia Minor. Sulla went to defeat him, and returned to take in hand the situation at home. Marius had created a "long service army," and so increased the power and prestige of every successful general for the future whose instrument the army naturally became. With the practical breakdown of normal government political power fell to such generals

and the military dictator becomes a familiar figure at Rome.

His transformation to "Imperator" or Emperor is easy and obvious, and so it is that the history of Rome in the last century B.C. is summed up in the story of such dictators struggling to exercise supreme power, always with a reliance on an army, until at last the genius of Cæsar was adequate to put this power on a permanent basis, for he was virtually, if not nominally, the first Roman Emperor.

Marius was elected consul five years in succession. He constituted himself the representative of the degenerate Roman populace, a veritable demagogue, using the readiest weapon to strike a blow at his hated rival Sulla. Sulla was by tradition and tastes the representative of the old aristocracy. Rome was now inevitably given over to party strife. While Sulla was away in the East, the Marians again seized the power in the state of which he had deprived them. A reign of terror ensued and there is a quality of brutality in the reprisals of this period never equalled in the most barbaric wars of the Middle Ages. Marius died, to be replaced by the demagogue Cinna, until he gave way before Sulla returned from the war and took vengeance by wholesale proscription.

This completed, he set up a new constitution under which the senate recovered all its ancient power. Then gracefully resigning the dictatorship, Sulla retired to spend a year in characteristic alternation between arduous study and the most abandoned pleasure and then died.

The Sullan constitution had no chance of permanence, and the old process went on, wars bringing great soldiers to the front, the rivalry of these for political power, the assassinations and intrigues through which Rome was to win her way to a new lease of life.

The next great soldier was Pompeius, who finally overthrew Mithridates, overran Syria, and took Jerusalem. Three new Roman provinces were set up in the midst of "a Roman sphere of influence." All this Pompeius carried through with vast labour and a wonderful mastery of detail, but going back to Rome with the knowledge that he must "work" the senatorial government to win its assent to the system. In this he was helped by the young C. Julius Cæsar, a youth of one of the highest families in Rome, but related to Pompeius by marriage. Cæsar had joined the popular party and had formed an alliance with Crassus, a soldier who had put down a great revolt of gladiators under the enlightened barbarian Spartacus. But Crassus owed his influence chiefly to his wealth. Together Cæsar and he had restored the old powers of the Tribunate, while Pompeius leaned rather to support the "Optimates."

Julius Cæsar.—Soon after the return of Pompeius Cæsar went to take up the command in Gaul which Pompeius has procured him by way of reward for his help. Crassus went to fight in the East and was killed, while Cæsar began his conquest of Gaul with the subjugation of the Helvetii, a Gallic tribe from the country which is now Switzerland, and threatening the province of Trans-Alpine Gaul. Cæsar himself has told the story of his wonderful wars. They gave him the immense prestige necessary for the part he meant to play.

The glory of Pompeius dwindled before it, and he and his party began to plot against Cæsar. Cæsar, in defiance of the law, led his army across the Rubicon. Pompeius crossed the Adriatic and Cæsar followed to defeat him at the Battle of Pharsalia in 48 B.C.

Pompeius fled to Egypt only to be struck down by an assassin as he set foot on shore. In Spain and in Africa Cæsar crushed the party of his dead rival, finding time to visit Italy and put order there between whiles.

Julius Cæsar stood apart from all successful generals before him. Having risen through a party, he ceased to be a party man, but devoted all the force of his genius to put affairs in the Roman world on a permanently reformed basis.

He was made Perpetual Dictator, and had a free hand for reform. He reorganized the whole Roman system, replacing it by an imperial government which was the only solution of the chaos into which things had fallen. All officers of state and all governors of provinces were henceforth nominated by him and responsible to him, and this was his root reform. It put the empire on a basis which gave it a new lease of life and prosperity which lasted for several centuries.

Large colonies of Roman citizens were planted out in the provinces, and the privilege of Roman citizenship was now extended to favoured ones among the provincials, so that Paul of Tarsus could defy merely local powers with a proud appeal to Rome.

Julius Cæsar had the fearlessness which has marked many of the world's greatest men and the generosity and readiness to forgive which has marked a few. He refused to stand on his guard against the jealousy of lesser men, and so was the easier victim to their malice. He was murdered in the Senate House on the 15th March in the year 44 B.C.

Yet so solid was the system he had built up that almost inevitably, though with an interval, his nephew Octavianus, his adopted heir, succeeded to Cæsar's power with the personal title of Augustus, which his successor too received, but which became a minor title. The more permanent title of Imperator, or Emperor, originally indicated that Augustus had the fullness of military power over the Roman world, which now included all Europe west of the Rhine and south of the Danube, all

Asia as far as the Euphrates with the exception of Arabia, and Egypt and North Africa between the desert and the sea.

The Imperial System.—It was in the centuries after Cæsar's great reorganization that the Roman imperial system received its greatest and best development. The empire was covered with a network of roads all leading to its heart at Rome. Roman colonies spread Roman culture over the civilized world, so that the western Mediterranean states became permanently Latinized. It was through the imperial system founded by Cæsar and sanely preserved by Augustus that Græco-Roman civilization was saved to the world, which it has since so profoundly modified.

A new era was ushered in with the Augustan age, so calm and suave in contrast to the years before, and with it the great spring of Latin literature bursts forth in the lyrics of Horace, the epic verse of Vergil, and the perfect prose of Livy.

One weak spot there was in the imperial system that it was not avowedly such. A fiction was maintained that the old constitution had not been radically changed. The emperor was but the "Principus," and there was no hereditary right of succession.

In normal periods the next of kin did actually succeed and men closed their eyes to the inconsistency between theory and practice, but there were times when there was no obvious heir, and the fight for the succession caused much bloodshed and misery in Rome. It would be impossible to do more than merely enumerate here the Roman emperors during the first three centuries of the empire, and this would not be of much advantage. The rule of the "Julian" emperors lasted till the year 70. They were so called because all had some claim of relationship or adoption on the family of Cæsar, though some of them at least owed their election to the Pretorian Guard. Nero, the cruellest and most lustful of tyrants, was the last of this group. His life gives the measure of the degree in which the empire had failed to root out the evil of luxury which had led to the ruin of the old constitution. There followed the Flavian emperors, so called from Titus Flavius Vespasianus, the first of the group, whose son Titus destroyed Jerusalem and sent the Jews forth as wanderers on the face of the earth. Then came the "good emperors" A.D. from 96 to 180, followed by the Antonines, of whom the most notable was the philosopher emperor, Marcus Aurelius, a man with all the natural virtues and with a resignation born of stoicism, a saint outside Christianity but for a morbid sadness which never co-exists with true sanctity.

The Spread of Christianity.—During these two centuries Christianity itself had, of course, been born, and was slowly but surely spreading among the populations of the empire. It represented a moral and spiritual revolution of supreme importance, but this was only realized at first by its professors.

The Roman Empire tolerated all religions so long as no refusal was given to the emperor worship, which was the guarantee of the state's security. Only the Jews had been exempted from this, for the authorities, though they themselves looked on the act of worship merely as an oath of allegiance, realized that it meant a violation of the Jewish conscience. The Christians, with their serenity and humility, were a standing reproach to the increasing sensuality which the growing prosperity of the empire begot. They often became social pariahs, and the notice of the state was attracted to them chiefly through private malice, so that the early persecutions were spasmodic and local rather than universal or systematic.

The great fire in Rome under Nero was attributed to the Christians, and the emperor, who had himself been accused of setting fire to the city, was glad to use them as scapegoats. Many Christians were burnt like living torches for the amusement of the Roman populace.

Marcus Aurelius was the first emperor who caused a persecution of the Christians by his direct authority. Yet Christianity made progress, working as a leaven quietly through all the empire, winning men to a new gentleness and a spiritualized morality. Christianity was not working wholly against alien forces. It found material ready to its hand. Besides the feverish desire for pleasure which led to the universal indulgence in the gross and brutal spectacles of the theatres, there was a world weariness morbid when without hope, but a powerful factor in the progress of Christianity when transformed by conviction.

The romantic and dramatic adoption by the Emperor Constantine of Christianity as the state religion was only possible by reason of the success already achieved. Constantine's sanction of Christianity was given in the year A.D. 313 after a great victory over a rival claimant to the empire.

There had been one great shock of persecution under Diocletian, under whom the experiment had been tried of dividing the imperial power between two emperors and two "Cæsars." Constantine was the son of Constantius, the Western Cæsar, and of Helen, a Christian. Under him the empire became united again. It might be interesting to speculate on the character which the Roman world would have now taken on had no new influence been brought to bear on it, but the world was on the eve of vast change, which heralds a new period in the history of the West.

THE MIDDLE AGES

Even in the days of Augustus it had been felt by far-seeing men that the Roman Empire

had expanded too quickly to allow of adequate defence, and for four centuries the authorities were constantly struggling with the problem of massing sufficient troops all along the frontiers to keep back the barbarians without.

It was this need which led to the partition of the empire under Diocletian, but the jealousies of rival emperors were found to be a disadvantage outweighing the advantages to frontier defence.

The "Middle Ages" began when the barbarians at last broke through and swarmed over the lands of the empire to mingle with the populations in varying proportions, and so to found the nations of modern Europe. The success of the barbarian invasions has often been ascribed to a vital decay in the empire, and it used to be the tradition to draw a vivid contrast between the decadent and luxurious provincial and his rude but virtuous conqueror. There is no truth in this view. Religion and morals within the empire were purer than among its invaders, as the wonderful spread of Christianity testifies.

Nor were the Roman soldiers deficient in either courage or fighting power. Only a great change had come over the army. Universal service had been abandoned, and professional armies wholly devoted to their generals were largely enlisted from the barbarians on the frontiers and even from the slave population. Naturally these men were not enthusiastic in the struggle with the barbarians without.

Moreover, thoughout the empire a spirit of indifference to the state had spread. The growth of class burdens and class privileges accounted for this. Vigorous political life was impossible in face of the growing bureaucratism and militarism of the empire.

The old tradition that Christianity was a hostile force working against the empire has just this much truth in it, that to those people who must have an enthusiasm Christianity furnished an object, while on its Quietist side it furnished an additional sanction of the spirit of acquiescence already abroad.

In one sense the provinces had already ceased to be Roman before the fall of the Roman Empire in that they had no part in Roman life. Even the cosmopolitanism, which such an empire might have been expected to foster, was prevented by the laws which kept the taxable population almost stationary for fear of evasion of due payment.

When the catastrophe at last came a shrunken empire extended itself in the East. Constantine had built a new Rome at the old Greek city of Byzantium on the Golden Horn, and there made his court. The city was called Constantinople after its founder, and became the political capital of the empire. The emperors became more and more eastern in their sympathies. One notable result of this policy was that a freer rein was given to the pontifical power of the Bishop of Rome or the Pope, and to the growth of a new world power in his spiritual jurisdiction.

In the year 395 A.D., on the death of the old Emperor Theodosius, the experiment of partition was revived. His son Arcadius received the East, and Honorius the West. The line of partition was drawn from the middle Danube to Durazzo on the coast of the Adriatic, and thence to the Gulf of Sidra. It was a logical division. To the east lay the lands where Greek was chiefly spoken, provinces with Alexandria and Antioch and Constantinople as their capitals. To the west lay the Latin speaking peoples.

But one great weakness in it was that the Eastern Empire did not feel that it was vital to guard the Danubian frontier to the north of the Balkan peninsula, and so left it very weak. Thus a direct passage was left for the barbarians to advance into Italy. Stilicho, the brilliant general of Honorius, and himself a barbarian, with an able man's impatience of inefficiency, took upon himself to interfere in the Balkan peninsula, and even to meddle with politics in Constantinople itself.

But Stilicho fell untimely. Honorius was persuaded unjustly that he was a traitor and he was executed. The seeds of dissension between East and West developed rapidly. Meanwhile two years after the fall of Stilicho, in the year 410, Alaric the Goth led a conquering army to Rome.

The city was sacked, but even in the midst of victory the barbarians were dazzled by the greatness of Rome. Alaric did not proclaim himself emperor or king, but was content to rule with the title of commander-in-chief of the Roman armies. Soon afterwards he died, and Athaulf, who succeeded him, led his armies out of Italy again into Gaul and thence south, driving before him the Vandals, a particularly coarse and brutal branch of these barbarians, into the north of Africa, where they spread themselves like a pest, almost stamping out the wonderful civilization which had its centre at Alexandria.

The Goths formed a vast dominion over the south-west of Gaul and the greater part of Spain. To another Teutonic group, the Franks, fell the greater part of Gaul on both sides of the Rhine, while the south-east of Gaul was won by the Burgundians.

The Fall of Rome.—The Roman Empire then had already fallen, and the acquiescence of Rome in the accomplished fact is seen when Visigoths (or western Goths), Franks, and the imperial armies joined in the overthrow of a new foe, the savage Huns, under their strange leader Attila, whose death soon after presaged the disappearance of this tribe from history.

But the traditional and dramatic fall of the empire is dated at the moment when the last decadent Roman emperor, bearing the honoured names of Romulus and Augustus, but called

in derision for his weakness Romulus Augustulus, was deposed by Odoacer the Herulian, who was content with the title of Patrician, and humbly recognized the rights of the Eastern emperor over Italy.

But these were only nominal rights, and their recognition but gave colour of legality to the new régime. The formal ending of the Western Roman Empire took place in 476 A.D.

Before many years Odoacer's power fell before that of Theodoric, the Amaling chief of the Eastern Goths or Ostrogoths. He was a man of immense ability, and, like all the better sort of barbarians, full of enthusiasm for Roman civilization.

In the thirty years during which he ruled Italy he tried to weld Roman and barbarian into one great nation. He made his capital at Ravenna, feeling no doubt that at Rome his power was overshadowed by that of the Pope. One great handicap he had. The Ostrogoths had been converted to Christianity, but to an heretical form of it.

Ever since the Egyptian priest Arius had taught in the early part of the fourth century that Christ was not perfectly equal with the Father, there had been a split among the Christians. Many had held to the teaching of Arius in spite of its condemnation by the Council of Nicæa called by Constantine in 325 A.D.

The barbarians who were converted to Arianism were never so successful in winning the good-will of the conquered populations as were orthodox conquerors like the Franks.

Then, again, the Eastern emperors yielded less reluctantly to the thought of losing Gaul or Spain than Italy, which after all was the true heart of empire.

After the death of Theodoric in 526 Italy fell to his feeble nephew, but the great Emperor Justinian determined to win it back for the empire and succeeded. One main result of his achievement was the adoption of his great *Corpus Juris*, or Code of Roman Laws, by the Italians. Roman Law was the greatest gift the Romans gave to the later world, and it was largely through its study in the Italian schools of a later day that it so profoundly influenced the laws of all European states.

The barbarians, for the most part, kept their own laws just as they imposed their Teutonic form of society on the conquered lands, but they sometimes codified the Roman laws which they found in force among the Provincials, and in time their own laws were tinged by elements of Roman Law. Only in England did Roman Law vanish altogether, which is one of the main arguments of those who hold that the Angles, Saxons, and Jutes, the Teutonic tribes who invaded this outlying province (already abandoned by the Romans in 410), destroyed entirely the conquered population.

With the death of Justinian and his great general Belisarius in 565 A.D. the power of the empire over Italy fell away and she lay open to new hordes of invaders.

The Eastern Empire.—The only effect of Justinian's efforts was to retard indefinitely the unification of Italy. Praise is due to him as one of the ablest of these Eastern emperors who, though they failed in the West, still held way against the Slavonic and Mongolian barbarians on the Danube and the Persian empire on the Euphrates.

This Eastern empire, too, after all maintained the traditions of classical civilization in a Greek rather than a Latin form. Constantinople was to withstand the shock of invasion for another thousand years, and when it fell at last before the Turk, the West, which had been laboriously building up a civilization for centuries, was intoxicated by the beauty of its culture.

Even after Justinian's death there was for long an Exarch at Ravenna, whose nominal power only served to divide North from South and further complicate the political condition of Italy. The middle district, which became afterwards the Papal States, and Venice alone owned allegiance to the empire. Into the North the Longobardians or Lombards poured to conquer. There were others in the South, where there was too a large Greek element still in nominal dependence on the empire.

The Remodelling of the West.—It is to be remarked that in all the countries round the Mediterranean the Latin element in the population triumphed over the conquerors. Often these were few in proportion to the numbers of the people they subdued, and intermarriage was inevitably followed by the adoption of the Latinized language of the conquered people.

So it happened in Spain, where the Iberian or pre-Aryan population had previously triumphed over the Celts, and the Latinized Celto-Iberian population now swamped the Gothic invaders as it was to swamp a new enemy which was shortly to threaten all these new peoples of the West.

In England, on the other hand, hardly a trace of the Roman civilization survived to leaven the Teutonic society and organization. Britain, visited twice by Julius Cæsar and conquered a century after his time, had after all received but a veneer of Roman civilization, and this only in its cities. It easily fell away.

Beyond the Rhine, where the Roman influence had never been very stable, the same thing happened, but in Gaul, which fell largely to the Franks, the Latin element prevailed.

There the Celtic element had largely predominated over the pre-Aryan, and now Celt and Teuton were to mingle to make the French people, but with a Latin language and a Latin culture.

The Franks were in many ways the greatest of these barbarian invaders. Before the end of the eighth century they had established themselves either as chief or sole power in all the provinces of the West except Britain, Spain, and Africa. It must be clearly understood that it was several centuries before national boundaries even approximating to modern divisions emerged.

The Franks possessed during many years what are modern France and Germany with immense influence in the north of Italy. For long the Franks had marauded the empire in the neighbourhood of the Rhine, and had been chastized by the emperors. They took for themselves the land round the mouths of the Scheldt and Rhine, and from those their power gradually spread.

The Frankish King Clovis, who became king at Tournai in 481, is the first great name in their history. In a struggle with the Allemanni, whose country (now Suabia) he conquered, Clovis consented to fight in the name of Christ, and, conquering, became Christian and all his nation with him.

Fortunately for himself he adopted the orthodox religion, and soon he found that it "irked" him "that Arians should rule in Gaul," and he forthwith conquered Gaul as far as the Pyrenees, and Paris became his capital. Clovis lived and prospered for many years a fervid Christian, but none the less ruthless, removing from his path all who threatened his welfare. He is a typical example of the spirit in which the barbarians received Christianity and the limitations in their observance of its precepts.

It was indeed a curious half savage material which Christianity had to mould in those days. Churchmen themselves often deteriorated in the process, but all that was saved and handed on of Roman civilization owed its preservation mainly to the Church.

The early monastic movement which spread from East to West in the fifth century had an immense refining influence on the people. In the beginning of the sixth century it received a great impulse from the spread of the rule given by St. Benedict of Nursia to his great monastery at Monte Cassino. Benedictine monasteries soon spread throughout the West and became centres of learning and industry—homes, too, of peace contrasting vividly with the turmoil without while a new world was in the making. The papacy, too, was becoming more and more a great spiritual power. Popes Innocent and Leo had awed the barbarians Alaric and Attila, and dissuaded them from their work of destruction, and the personality of Gregory the Great, pope from 590–604, made itself widely felt. It was Gregory, himself a Benedictine monk, who sent St. Augustine, another Benedictine, to convert England, although already the Gospel had been preached in the North by the less highly organized but extremely spiritual Columban monks from Iona, an offshoot of Irish monasticism. Through Gregory's efforts Latin and not Celtic Christianity prevailed in England, and English missionaries in their turn went out to convert the heathen tribes on the German side of the Rhine.

After the death of Clovis the Frankish power was extended over the Burgundians, Bavarians, Thuringians, and the Ostrogoths of Provence. Naturally the Frankish dominions then fell into three parts—Austria, or the land of the Eastern Franks, Neustria of the Western Franks, and the middle kingdom of Burgundy. The Franks clung more than the other barbarians to the Teutonic custom of partitioning a man's dominions between all his sons, and so those three kingdoms were often in separate hands, only to be reunited when the strongest prince had succeeded in slaying his relatives. The internal history of the Merovingians in the later sixth and the greater part of the seventh century is full of crime and crude passion.

For the most part the Merovingians were feeble figure heads, and in all three divisions (for each had their separate administration) it was the king's chief officer, known as the Mayor of the Palace, who was the real power behind the throne.

At last Charles Martel, the Austrasian *Major-Domi*, got the show as well as the reality of power, and founded the Carolingian dynasty. He won his greatest prestige from his epoch-making victory over the Mohammedan Arabs in 732 B.C.

The Rise of Islam.—For a century before this the great new force of Mohammedanism had been carrying all before it. The "revelation" of Mohammed, an Arabian desert dreamer, that there was but one God and Mohammed was his prophet had seized upon the imagination of the Arabians. In reality Mohammed's teaching arose from conceptions he had gleaned from Judaism and Christianity mingled with other more material elements, but after the first few years of discouragement it was received as a new gospel.

The Mohammedan era dates from Mohammed's "Flight" from Mecca in the year A.D. 622. He returned in triumph eight years later, and the worship paid to idols in the sacred city was transferred to the True God. It became characteristic of the Mohammedan faith that its followers must proselytize. With the Koran in one hand and a sword in the other the Arabians after Mohammed's death began a vast career of conquest.

Arabia had come into allegiance almost to a man, and some false prophets who arose were easily put down. The first great conquering "Kaliph" was Omar, who overcame the Persians and carried the Moslem power as far as the

Euphrates. The Eastern Empire, which had warded off the aggression of Persia, could not withstand the shock of Islam, and Syria was lost to it.

Belisarius had won back North Africa from the Vandals, but this was easily overrun by the Mohammedans. The classic city of Alexandria fell and a new Moslem capital, Cairo, took its place. There were soon internal divisions among the Mohammedans themselves, and an Eastern kaliphate at Bagdad was rivalled by another in the far West. But this hardly stayed at all the process of conquest. From Africa the Saracens crossed into Spain and overran the land. They became known here as the Moors. In Asia Minor, too, their power spread.

It seemed that the Western world might fall to the Mohammedans when almost simultaneously in East and West they received a tremendous check. Leo the Isaurian, called the Iconoclast because he sanctioned the party in the Eastern Church which protested against the use of images, by a great victory in A.D. 717 drove the Saracens back from the very gates of Constantinople, and so saved a shrunken empire from Mohammedanism for nearly 800 years. A few years later Charles Martel repulsed the Moors advancing from Spain into France at the battle of Tours in 732.

Thus bounds were set to the advance of Islam, but most of Western Asia had succumbed, and North Africa and Spain. The history of mediæval Spain is the romantic story of the steps by which the land was slowly won back by the Christians from the Moors. Yet the Mohammedans in Spain were the most civilized people in Europe in the early Middle Ages. There was much freedom of discussion among them, and they were the pioneers of the mediæval study of Greek philosophy, though naturally they gave their own colouring to its interpretation.

Charles Martel, who had saved France and presumably the greater part of Europe from the Saracens, was never king of the Franks, but his son, Pepin the Short, took the title as well as the power of king, the puppet Merovingian, with the approval of the pope, retiring into a monastery. Pepin only paid his debt to the papacy when he marched into Italy, conquered the Lombards of the North, who were threatening the secular power of the pope in Rome, and handed over the central provinces of Italy to the pope, thus laying the foundation of the "Temporal Power" of the papacy.

Charles the Great.—At Pepin's death his dominions were as usual divided, but his son Carloman soon died too, and the whole fell to his brother Charles, the Emperor Charles the Great, one of the greatest men of the Middle

dominions stretched from the Atlantic to the borders of Bohemia and from the North Sea to the Pyrenees. It was a vast empire and Charles brought a new idealism to its administration.

In spite of the prevalence of the French form of his name, Charlemagne, Charles was no Frenchman. He was a German, and had his capital at the German town of Aachen or Aix-la-Chapelle. Charles was a great soldier and general. He had little education, but he was clever and quick, a seer of visions, a reformer and administrator. He went from conquest to conquest, subduing North Italy and the remote Saxon tribes, and setting up law and order throughout his dominions.

He marched into Spain against the Kaliph of Cordova, and the death of his nephew, the brave knight Roland, forms the theme of the *Chanson de Roland*, the first of the famous cycle of epics built round the memory of Charles the Great. With the vast extension of his empire, and with Charles what he was, the dramatic revival of the Roman Empire of the West in his person seems almost an inevitable development.

On Christmas Day in the year 800 Pope Leo III crowned Charles emperor in the Church of St. Peter at Rome, and so began that institution marvellous in its success and its failure, the Holy Roman Empire.

Henceforth there were no more fictions about the supremacy of the emperor at Constantinople. Politically Europe was split into East and West, and soon the Eastern Church was also to part company from the Western in a schism which has never been healed to this day.

Charles had a peculiarly noble conception of the scope and mission of the revived empire. The emperor was to be above kings, even above popes as a moral and spiritual force in the world. The Church, under his guidance, was to educate and civilize the people, and Charles was a great founder of schools.

On the political side the revival of the empire had little influence; it affected not at all the Teutonic organization and government of Charles's empire. Charles, like all Teutonic kings, governed with the counsel of the great men of his dominions. There was the customary tradition, too, by which the assemblies of free men had a voice in questions of war and peace, and because this was little effective in such vast dominions Charles sent "missi dominici" as inspectors of the administration of the counts who held sway outside the tribal duchies and whose power tended to become hereditary.

The Growth of Feudalism.—The empire did not stop the growth of that feudalism which was to be the form of society for the next few hundred years, but Charles's government held it in check.

The essence of feudalism is that political and judicial power go hand in hand with the

possession of land. In feudal theory the king is owner of all the land, some of which he keeps as his own "demesne" land and the rest he gives out to the great men who have done him service in war—the noble class. These in return owe him homage and military service, and sometimes other payments. The great lords in their turn parcel out their land to lesser tenants who stand in relation to them as they do to the king.

A strong king can override the greater lords and prevent the allegiance of the lesser tenants ever being used against himself. He can also interfere in judicial matters, and the growth of a strong monarchy is marked by the reduction of the scope of private jurisdiction and its ultimate destruction.

But where feudalism was strong the king was weak, and countries were broken up into feudal principalities in which the great lords secular, and in the lands of the empire more often ecclesiastical, could wield the power of life and death.

At the bottom of the feudal scale was the serf, little better than the slave of Greek and Roman times.

When feudalism flourished unchecked this class and indeed all lesser men suffered horribly from the constant violence and bloodshed caused by the continual fights between the great lords. At times when the central or kingly power kept a strong hand over the great lords the condition of the serf was ameliorated by force of custom and public opinion.

The Church encouraged the manumission of serfs, and the more adventurous often escaped to the towns, where, if they went free for a year and a day, no one could reclaim them.

There had been a beginning of feudalism even before the barbarian period when, with the weakening of the central government at Rome, great provincial proprietors arrogated to themselves vast judicial powers. The germ of the tendency existed too in the Teutonic bond between the war leader and the war band, and an immense impetus was given to the system of commendation by which men acknowledged a lord for the sake of his protection when Europe in the eighth and ninth centuries was attacked by new hordes of barbarians, the fierce Northmen who came chiefly out of Scandinavia to prey upon the lands to the south.

Charles the Great had been saddened when he contemplated this danger. After his death in 814 they came in greater force. Nor was there any central power to withstand them, for with Charles's death his empire broke up more or less into its natural divisions.

The West or Latinized part became France, thus retaining the name of the Teutonic conquerors. The East became Germany, while there was a constantly diminishing "Middle Kingdom" which ultimately was divided between the two. The imperial power became but a name attached to one or other of the successors of Charles until some of its glamour was revived in the tenth century, when began that rivalry for power between pope and emperor which plays so large a part in the later Middle Ages.

The Dark Ages.—The papacy in the days after Charles the Great sank even lower than the empire. In many ways the ninth century and first half of the tenth form a true "Dark Age."

Everywhere in the ninth century Europe was fighting against fierce enemies. In the West were the Northmen. In the East the Mediterranean was infested by Saracen pirates. Germany and Italy were threatened before the end of the century by the Hungarians, supposed by contemporaries to be identical with the Huns of Attila. They were finally defeated upon the Lech in 955, and settled down in the land which was called Hungary after them. But they had contributed their share to the disorders of the period.

The Saracen power at this time was being swamped by hordes of Turks, who were pushing their way into the Moslem Empire, adopting its tenets. They became finally the dominant force in that empire, with an even fiercer zeal for conquest than their predecessors, until their challenge concentrated all the energies of the West in the vast Crusading movement at the end of the eleventh century.

The Northern pirates had begun to attack the British Isles and Frisia even before the death of Charles the Great, and immediately after it they attacked the whole coast-line from the Elbe to the Pyrenees.

At the end of the century there was a sudden break in the stream of aggression, but half England and all Normandy had been won by the Danes.

Painfully Saxon England had achieved some kind of unity under the Wessex kings when the Danes attacked it, and it was for the Wessex kings to defend England against the invader. All that the genius of Alfred the Great could do was to save England west of the great Roman road, Watling Street, for the English. The rest became the "Danelaw."

But these Northmen had a vast power of assimilation, and in time became English themselves sometimes under Danish kings, but more often under English, so that England was a united kingdom, except for a strong feudal tendency owing to the weakness of her later kings, when in 1066 she was conquered by the Northmen of Normandy, who, in their turn, had become more French than the French.

The Norman Duke William the Conqueror, when he did win England, saw to it that the feudal elements were held in check by the royal power, and England early became an outstanding example of the new strong monarchies

which were to be built up on the ruin of feudalism.

In France the same process began, when Hugh Capet, the representative of a house which had long ruled for the degenerate Carolingians, took the title of king in 987.

But in France the growth of a strong monarchy was a slower process than in England, and the Dukes of Normandy who had thus triumphed over feudalism in England were not the least troublesome of the feudal lords of France.

In Germany, too, the Saxon line beginning with Henry the Fowler (919–936) made the royal power hereditary, though his was but an ineffective kingship as far as the great Dukes were concerned. Suabia, Bavaria, and Lotharingia were dependent principalities in which Henry had hardly any power except as patron of the Church.

The Revival of the Empire.—It was Henry's son Otto who restored the empire to be something more than a name. He marched into Italy, where he was crowned king and next year emperor. He deposed the degenerate pope, and set up one of passable morality in his place, but it was left to his grandson, Otto III, to make a real effort to reform the papacy. Otto III was full of admiration for Roman tradition, and full too of reforming zeal. He practically made Rome his capital, and he placed a really spiritual man and another committed to reform, successively on the papal throne.

But Otto's neglect of Germany, in which like his father he swerved from his grandfather's policy of consolidating his power there, was a mistake, and only the Church party kept his power secure.

Otto III was a keen reformer of the Church, and in sympathy with the new spirit, which was spreading through Christendom at this time, and which has been called the Cluniac reform because it had its earliest striking manifestation in the severe reform of the monastery of Cluny in the south of France.

But the dreams of Otto III were entirely visionary. He was broken-hearted when the people of Rome, a degenerate population to which he attributed all the classic virtues, turned against him, and he wandered thenceforth in Italy, and died broken-hearted when only twenty-one years old. His successor, Henry of Bavaria, took up again a strong German policy.

For a while the papacy fell back into its former degradation, but revived again later under the Emperor Henry III. Several popes drawn from the German reforming party were successively elected. One of them, Leo IX, insisted on a clerical election in addition to the imperial nomination.

The Age of Hildebrand.—The reforming party were becoming more and more tenacious of ecclesiastical prestige, and finally the German monk Hildebrand, who became pope as Gregory VII in 1073, asserted boldly that the papacy was the supreme power in Christendom.

The emperor at this time was the child Henry IV. His minority strengthened the papal power, but when he grew to maturity the inevitable quarrel between empire and papacy broke out. It raged long over the subject of lay investitures, which was at last settled by way of compromise. Henry IV was driven to humble himself to have the sentence of excommunication removed which encouraged his subjects to rebel, but he later drove Gregory into the exile in which he died.

The Empire and the Papacy.—The struggle, or rather three separate struggles, covers a period of 200 years. The quarrel with Henry IV continued under his successor Henry V, who was emperor from 1106 to 1125. It was resumed again under the great Emperor Frederick Barbarossa (1152–1190), and yet again under his grandson, the brilliant Frederick II (1212–1250).

Always there were different causes of quarrel, but at bottom it was a duel for superiority between Church and State. The Church was fighting for its "freedom," and triumphed in each quarrel largely because it was able to enlist secular allies with various motives for enmity against the enemy of the Church, but partly too because of its moral and spiritual hold on the people.

It is to be noted that the period in which the sacerdotal claims were highest was also the period of the highest enthusiasm for the spiritual life. The Cluniac movement was followed by the rise of the great Cistercian, Carthusian, and other orders of monks. It was from Innocent III, the remarkable pope under whom papal claims were most compelling, that the new orders of Friars, the Dominicans and Franciscans, vowed to preaching and poverty, first sought approval. Those two centuries too were the age of the Crusades.

The Crusades.—This movement is one of the most remarkable in all history. Through it great masses of people from nations which had long settled down became, as it were, nomadic again. Great armies went forth from the West, and hurled themselves against the Turk with the avowed and main motive of rescuing the Sepulchre of Christ from the infidel, and making it easily accessible again for the Christian pilgrims.

But just as mediæval Christianity was always limited in its action by the passions of a people but newly redeemed from barbarism, so there were many mingled motives in the prosecution of the Crusades. Some men went for mere adventure, others for fame or profit, but always there was the colour of a religious motive, and

but for the religious element the Crusades would have been impossible. Alexius the Eastern emperor called in vain for help until Peter the Hermit, returning from the Holy Land, roused the peoples of Europe to a frenzy with his tale of the persecution of the Christian pilgrims by the Turks.

Before an organized army could be got together a great crowd of enthusiastic and ill-armed peasants and poor folk set off under the leadership of Peter himself and Walter the Penniless, and being a mere rabble committing outrages wherever they went were mostly cut to pieces long before the Holy Land was reached.

In the same year, 1096, the first real crusading army set forth. It was an army, like all the crusading armies, of volunteers officered by volunteers, and in no wise a national force.

Prominent among the leaders was Robert, the son of William the Conqueror, and brother of William Rufus, King of England, to whom he virtually resigned his Norman duchy for the expenses of his Crusade. There was, too, Godfrey de Bouillon, Duke of Lower Lorraine, the type of the perfect knight and hero of the Crusade.

The First Crusade was the only one of the Crusades which met with a real measure of success. Jerusalem was taken, and became the centre of a new Latin kingdom of Jerusalem with Godfrey as its king. There is something very romantic in this establishemnt of a feudal Latin kingdom on Eastern soil. From this time for two centuries constant streams of crusaders, knights and lesser men, flowed to and from the Holy Land.

All through the fourteenth and fifteenth centuries there was talk of a Crusade, but there the movement ended. The last Crusade, which was in any sense a real one, was the ninth in 1272, in which St. Louis, King of France, died, and whose leadership fell to Edward of England, afterwards Edward I.

The Latin kingdom had been reconquered long before this, and Jerusalem remained in the hands of the Turks, though pilgrims were allowed free access to the Holy Sepulchre. One picturesque and curious result of the Crusades was the setting up of the military orders, monks in time of peace and soldiers in time of war. The chief of these were the Knights Templars, and the Knights Hospitallers.

The Crusading movement might seem to have been somewhat fruitless, but it had indirectly brought about much change. A movement in which the virtues and vices of feudalism found full scope, its net result was to militate against the feudal form of society. Often the burghers of a town bought release from their feudal obligations from a needy crusading lord. And it was the free towns which, forming a network throughout the lands of Europe, did most to break down the fences of feudal society.

More obvious is the increasing interchange of commodities, a trade which made Venice rich, an increase too in common knowledge of men and manners, and to some extent an interchange of ideas between East and West, though it is easy to exaggerate this.

Meanwhile in France and England at least the sway of feudalism was being undermined by the growth of strongly centralized monarchies. From the time of the Conquest the Norman kings had been careful to control the feudal nobles. In the first years after the Conquest England had been obviously a conquered state. Nearly all the old English nobles were dead, and their women married with the new Norman aristocracy. The conquerors spoke a different language (Norman French), and had finer manners. But as time went on the English elements, modified in the direction of refinement, prevailed, but well into the fourteenth century the noble class was bilingual.

The Angevin dynasty which succeeded the Norman developed an elaborate centralized system of government, but between the reigns of Henry I and Henry II, England had tasted the horrors of feudalism under the weak rule of Stephen.

The Full Middle Age.—The Angevin system was a despotism, and when it fell into the hands of a tyrant like John it was no longer a means of protecting the weak against the strong, but an instrument of oppression of all classes. The *Great Charter* forced upon John by Stephen Langton and the Barons prescribed freedom for all. It was but a feudal document, and provided no adequate restraint of a determined tyrant, but it manifested a spirit which future kings must mark.

Under John's amiable but weak son, Henry III, discontent grew to rebellion because of the king's favours to foreigners, and Simon de Montfort fought for good government, and died for it at Evesham. Henry's son, the great and good King Edward I, learned from his father's experience. He determined to rule equably but strongly. He practically eliminated the feudal element from political life. He was a great conqueror, winning Wales and dreaming of uniting the British Isles under his rule. He failed with Scotland. Ireland had been annexed under Henry II, and English rule was efficient in the district round Dublin. But most of all Edward I is remembered as the "founder" of the English Parliament. He adopted as a permanent method the representation of the middle classes and towns by knights of the shire and burghers which had been first devised by the genius of Simon de Montfort.

Parliamentary government in England was to have a chequered history, but from this time the forms were always there to make English constitutional history unique among nations.

In France, too, a strong monarchy had been

built up to the weakening of feudalism, but there was no alliance between king and people.

From the first the French monarchy was a despotism, and herein lies the germs of all the difference between these two countries. The loss of Normandy to the French by John helped much towards the unification of France, but the great block of territory in the south of France which had been brought to the English crown by Henry II was always an eyesore to the French, and the true secret of the constant warfare between England and France in the later Middle Ages.

Meanwhile Germany was as much broken up as ever. The German kings, sometimes with the title of emperor, sometimes without, had little power in the greater part of Germany except over the towns which here as elsewhere shook themselves free from the trammels of feudalism.

In Italy the greater cities gradually became centres governing subject territories, so that at the end of the Middle Ages it was divided among Venice ruled by its close oligarchy, Florence, once a brilliant democracy, now controlled by the Medici family, Milan ruled by the Dukes of Milan, the Papal States under the Popes, and the kingdom of Naples and Sicily, carved out by the Normans in the thirteenth century, tossed from one dynasty to another.

The empire during the later Middle Ages had become but the shadow of a name. The papacy too, after its brilliant time under Innocent III, had fallen from its high estate. Under Pope Boniface VIII, at the end of the thirteenth century its pretensions were more magnificent than ever before. The pope forbade the secular authorities to tax the clergy without his permission. Even so good a Churchman as Edward I of England would not agree to this, and the brutal Philip IV the Fair, of France, carried his resentment so far as to declare that France was independent of the pope, and to send soldiers to attack the old pope in his palace, where he died of shock soon afterwards.

This was in 1294. The French in a few years secured the election of a Frenchman to the papal throne who in 1305, instead of going to Rome, set up his court at Avignon in the south of France, though actually belonging to the King of Naples. Here with one short interval the popes remained till 1377, and this period in its history is generally described as the Babylonian captivity, though the extent of the dependence of the popes on the French kings has been much exaggerated.

The fourteeonth century shows a somewhat gloomy phase of mediæval history all over Europe in contrast to the brilliant vivacity of the thirteenth. There has been no space to dwell on the movement in art and literature which accompanied the religious revival of the twelfth and thirteenth centuries, of the growth of the scholastic philosophy which culminated in the brilliant and subtle writings of the Dominican, St. Thomas Aquinas, in the thirteenth century, of the gay troubadour poetry of Southern France so irresponsible in spirit, of the development of the study of law, which with philosophy and theology formed the staple of education at the universities which grew out of the schools thronged with teachers and scholars in the twelfth century. Gothic architecture, that supreme art of the Middle Ages, had achieved its sanest and noblest results in the thirteenth century.

The End of the Middle Ages.—But the fourteenth century showed unrest rather than vivacity. There had been heretics with strange teachings in the twelfth and thirteenth centuries. They had been ruthlessly stamped out. The fourteenth century brought a new grimness and doggedness to bear on these questions. The teaching of the priest John Wycliff in England militated against both Church and State as then constituted. There was a new hatred between class and class, and for the first time these feelings found some form of permanent, if crude expression. In England the Peasants' Revolt, in France the Jacquerie give evidence of the widespread discontent. Three successive visitations of the Black Death, a plague sweeping over Europe from the East and decimating the population, aggravated the social and economic evils. There is something very modern in the problems at this time of the relation between labourer and employer. A brighter feature of the times is the development of a true vernacular literature with the poetry of Chaucer in England, Dante, who belongs to the later thirteenth and early fourteenth century, in Italy, and Petrarch. But Italy with its cities growing ever wealthier is an exception to the general gloom of the period.

The intermittent fighting between England and France known as the Hundred Years War did no good to either country, and is chiefly of interest to the historian of military tactics, and as a permanent object lesson of how the sturdy English bowmen overmatched time and again the proud chivalry of France. The Hundred Years War atones for itself, however, in that it gave Joan of Arc to be the saviour of France.

But this was in the fifteenth century, whose first half was but a continuation of the character of the fourteenth century.

Then midway through the century, twenty years after the burning of Joan of Arc at Rouen, the Hundred Years War came to an end. France had practically gained her natural boundaries at last, and England held only Calais of all her ancient French dominion. The French crown grew stronger, and the nation recovered quickly from the effects of the war.

In England, too, in spite of the faction fights known as the Wars of the Roses, the nation grew more prosperous, and especially was to be noted the increase of the middle class, while the old nobility was almost annihilated.

In Spain at the end of the century the marriage of Ferdinand of Aragon and Isabella of Castile united practically all Spain, though Portugal remained permanently a separate kingdom. The driving of the Moors from Granada, their last stronghold in the south of Spain, gave the country its modern boundaries.

The papacy had returned to Rome in 1377, but had to suffer the strain of the "Great Schism," which was only healed at the election of Pope Martin V in 1417. At the Council of Constance, which ended the schism, the famous John Huss, a Bohemian disciple of Wycliff, and his friend Jerome of Prague were condemned for heresy and burnt at the stake. But a long struggle with the Hussites in Bohemia was necessary before even a compromise was achieved between the heretics and the Church. It was hardly a conquest.

But conditions were preparing which were to make immense differences in the opportunity of promulgating new teaching in the future. There was little in the teaching of Luther at first to distinguish it in power from that of Wycliff or Huss, but the whole world had changed since their day, changes which may be summed up in the descriptive word "Renaissance." With the Renaissance and the Reformation modern history may be said to begin.

THE RENAISSANCE AND THE REFORMATION

At the beginning of the sixteenth century the great states of Europe had for the most part taken shape. England was united under the strong Tudor despotism built up on the ruins of the old nobility. She was soon to take her place as one of the four great states. The others were France, Spain, and Austria. The great House of Hapsburg had built up enormous power for itself centreing in its hereditary dominions of Austria. Its inheritance also included claims on the crowns of Hungary and Bohemia, and the position of emperor had become hereditary in the house. Through marriages the Emperor Charles V succeeded to these dominions and also to Spain, the Free Country of Burgundy, and the Low Countries (now Holland and Belgium). He became emperor in 1519, and naturally his succession was regarded as a menace to what afterwards came to be called the "Balance of Power" in Europe.

It seemed that Charles might dominate Europe, but he was always hampered by the divisions within the empire itself, and when at last he resigned his power his dominions were divided, the Austrian portion going to his brother Ferdinand, and the rest, still a swollen dominion, to his son the famous Philip II of Spain.

But long before this great changes had come to pass in Europe. At the end of the fifteenth century a new spirit seems to have passed over the world, an eagerness and unrest, but constructive and not merely critical like the unrest of the fourteenth century. It was this new spirit which was the chief element in the Renaissance movement.

It was once the fashion to say that the Renaissance began when in 1453 Constantinople at last fell before the Turks and Greek scholars fled West, carrying with them the manuscripts containing the treasures of ancient learning which the Eastern Empire has stored up so long. But this dispersal of the Greek scholars was only an opportune incident falling in wonderfully enough with the spirit of the age.

One strong element in the Renaissance movement was a reaction from the ascetic ideal of the Middle Ages to an enthusiasm for the worship of material beauty, which was the ideal of the Greeks and Romans. Greek, the study of which had been revived in the twelfth century but had never really spread even among scholars, was now looked upon as the key to all knowledge. Scholars everywhere, but especially in Italy, eagerly pursued the study of Greek with the aid of the exiles, and feverishly bought and copied all available manuscripts.

Statues and fragments of ancient art were eagerly collected and a new impetus was given to painting and the plastic arts. The Renaissance began early in Italy. In the latter half of the fifteenth century court rivalled court in enthusiasm for and patronage of the new scholarship. Popes and princes joined in the movement, but Florence under the Medici surpassed the rest.

The Renaissance in Italy.—The first flowering of the Renaissance in Italy, the new joy and wonder in life, was bruised when Charles VIII of France in 1494 led an expedition through the peninsula ostensibly to settle a quarrel between Italian princes, but really beginning that policy of aggression on the part of stronger states to which disunited Italy lay a natural victim for nearly four centuries longer.

Simultaneously with this reversion to classical ideals there developed a spirit of inquiry about the world and the universe. Portuguese explorers pushed their way south along the coast of Africa into unknown oceans, and finally round to India, while Columbus crossed the "Sea of Darkness" and made the discovery of the great continent of America there where the "edge of the world" had been supposed to be.

Copernicus, by his discovery that the earth is not the centre of the universe but a mere

satellite of the sun, revealed to men the first glimmering conceptions of the vastness of space. Man in relation to the universe was at once dwarfed and exalted.

At this moment then the world was teeming with new ideas. The invention of printing furthered their speedy dissemination from scholar to scholar and land to land. All this new thought and new enterprise go to make the Renaissance.

The movement began somewhat later in the other countries of Europe than in Italy, and it took on a soberer tinge. Some of the Renaissance scholars had posed as pagans, but they had not really brought their religion to the touchstone of the Renaissance. The soberer men of the North inevitably did so. The result was the Reformation.

In England, which the Renaissance in its gayer aspects reached late, a renewal of the study of Greek at the universities was followed by a movement for reform in the Church. The leaders were Sir Thomas More, who became Chancellor of England at the fall of Cardinal Wolsey, and John Colet, Dean of St. Paul's, who founded St. Paul's School for boys, where they should be taught Greek and brought up to a noble ideal of religion.

Associated with these was the world famous scholar, Erasmus of Rotterdam, who in his caustic and clever writings held up to ridicule the accretions and abuses of popular religion which these reformers denounced as mummeries. Erasmus made a new translation of the New Testament into Latin from the Greek, for a zeal for the purity of the Biblical text was one fruit of the new scholarship. But not one of these men contemplated any breach with the Church. They wanted reform from within, and they were furthered in their efforts by the far-seeing Cardinal Wolsey from motives of policy rather than spirituality.

Martin Luther and the Rise of Protestantism.—But reformation was to come by way of revolution, when the defiance flung to the pope by the German peasant friar, Martin Luther, was caught up and spread till half Europe was Protestant. Martin Luther quarrelled with the ecclesiastical authorities on the subject of indulgences, the system by which remission of punishment for sins already repented of and forgiven, could be obtained by good works which in time came to be a specified good work, such as the payment of money to charity or towards the building of a church, a development with obvious possibilities of corruption.

The papacy had fallen to its lowest depths in the last quarter of the fifteenth century, until with the Borgia Pope, Alexander VI, it touched the limits of vice and degradation. This degradation of the papacy had had its part in stimulating the movement for reform, but it was the quite respectable if worldly and unspiritual Leo X, a Medici, who was pope when Luther challenged the papacy.

Leo had granted an indulgence, the proceeds of which were to go to the completion of the great basilica of St. Peter at Rome, which was in course of building to Bramante's fine design. Tetzel, a Dominican, was selling these indulgences in Germany, and the people were flocking to buy when Luther angrily attacked the system. He was led on from a criticism of the theory of indulgences to question altogether the power of the papacy and the authority of the Catholic Church. Called to account for his opinions at the "Diet of Worms" in 1521, Luther refused to retract them, and with this Protestantism may be said to have begun. The Elector Frederick of Saxony spirited Luther away to the castle of Wartburg, fearing for him the fate of Huss. Under his patronage Luther preached, and wrote promulgating his characteristic doctrine of Justification by Faith, reducing the number of the Sacraments first to three and then to two, and whittling away the doctrine of Transubstantiation to that of Consubstantiation.

Luther would still have preserved a Church with authority to impose belief, but there was something in this new heretical attitude which appealed to the audacious spirit which the Renaissance had spread abroad, and soon in Germany there were almost as many churches as there were princes. All through his reign the Emperor Charles V strove to reconcile the Protestant attitude with Catholic authority, but failed.

From France the great reformer, John Calvin, fled to set up his church in Geneva, where he taught his rigid doctrine of Predestination and imposed his inquisitorial system of moral and spiritual discipline.

The teaching of Calvin had in it a strong germ of growth. It appealed to the fatalistic tendency in human thought, and Calvinism became the most proselytizing form of Protestantism. Scotland was early converted to it, as were some of the German states to which Lutheranism seemed but a compromise. The French Protestants, who were largely confined to the south of France, were Calvinists. The French monarchy and the bulk of the people remained consistently Catholic. In Switzerland, where each state was allowed to settle its own religion, the Protestant cantons for the most part advanced from the teaching of their own reformer Zwingli to the more ruthless doctrines of Calvin. The early Protestants in England drew their inspiration from Geneva, and were duly hunted out and burnt for their defiance by the second Tudor King, Henry VIII. It was by his zeal against Luther's teaching that Henry won for himself the title of "Defender of the Faith," and he always had an intellectual appreciation of Catholic dogma. But he

was soon to see the advantages to despotism of the new Protestantism, and more or less deliberately he gave England over to it.

The Reformation in England.—The adoption of the Protestant religion in England was a political step. There was no popular demand for it, and in fact the general feeling among the people was conservative, although, as we have seen, there was a Protestant leaven at work.

The crude story of Henry's life makes him little better than a monster, but the real key to his character, besides the strength of his lusts, is the unbounded egotism which was characteristic of the princes of the Renaissance.

To circumvent the pope's objection to his divorce from Katherine of Aragon, his wife for twenty years, Henry broke away from the papacy, and so was enabled to marry the maid of honour, Anne Boleyn.

Once committed to this course, Henry was determined to reap all its advantages. The men who stood in his way who would not take the oath of supremacy were executed, men like the inimitably witty lawyer, Sir Thomas More, and the saintly Bishop Fisher. The dissolution of all the ancient monasteries of England brought money into the royal coffers.

The confiscation of Church property had been one of the determining factors in the adoption of Protestantism by various German princes, and was the determining element in the adoption of Protestantism by Denmark and Sweden. Henry showed the utmost cynicism in this matter. He founded a new nobility with grants from the Church lands. Yet Henry's instincts were against Protestantism. He wanted a *via media*, and those who denied the doctrine of Transubstantiation or refused to believe that auricular confession was necessary, were condemned to the same horrible death as those who refused to transfer their allegiance from pope to king. So two streams of persecution flowed steadily until the reign went out in gloom.

With the accession of Henry's young son by Jane Seymour, Edward VI, in 1547, the Protestant party, whom the moderate policy of Henry had irked terribly, came into power, but Edward died in a few years, and Mary Tudor, the daughter of Katherine of Aragon, restored England with every circumstance of pageantry to the allegiance of the pope.

That she was not able to recover the monastic lands and refound the monasteries gives the measure of her failure. The mass of the English people in this period seem to have acquiesced silently in the vagaries of their rulers. But Mary's persecution of the Protestants gave a new fierceness to the Protestant propaganda. When Mary too died in a few years she was broken-hearted at her failures, and at the neglect of her husband, the great Philip of Spain, who had married her for political advantage.

Her half sister Elizabeth, the daughter of Henry and Anne Boleyn, the greatest Tudor of all and the most cynical, restored the Protestant faith. Singularly like her father in character, with a veneer of frivolity and vanity, a heritage from her mother, Elizabeth grappled with the problem of England's faith entirely in a political spirit.

She too declared for a *via media*, but the line was drawn nearer to the side of Protestantism. Avoiding the use of the title of "Head of the Church," somewhat anomalous in the case of a woman, she used all the substantial privileges of the position.

Catholics were hunted out and persecuted all through her reign, mainly because they seemed to threaten the political integrity of the realm.

Puritans, too, were persecuted for their extreme Protestant teaching. But the Elizabethan religion was accepted meekly by the bulk of Englishmen. The queen herself roused inordinate enthusiasm. She was, indeed, a consummate politician, and was determined to keep England in the forefront of the nations.

Elizabeth became queen in 1558, and for nearly thirty years, during which there was every motive for war, she kept England at peace. She dangled the prospect of her marriage as a prize or a menace before the eyes of the chief statesmen of Europe. She withstood her subjects in their insistent demand for war with Spain.

The Counter-Reformation.—From the first Spain had clung to Catholicism, and Philip II, who had succeeded to the great Spanish possessions in Europe and the New World in 1556, was the most ardent champion of that counter-Reformation within the Church which had followed hard upon the heels of the Reformation.

At first the counter-Reformation was but the reforming movement from the Catholic standpoint. Its leaders were anxious and hopeful for reconciliation with the Protestants. But the Council of Trent, which sat from 1545 to 1563, and engaged in a vast work of doctrinal definition, naturally moved no jot in the direction of Protestantism, and when the Council ended it was already realized that there could be no compromise.

But the papacy was now furnished with a vast army bent on winning back the Protestant lands to the old Faith. The Spanish nobleman, Ignatius of Loyola, had brought into being in 1540 that wonderful society known as the Jesuits; and some of the older orders too had received a new impetus to better things.

The Jesuits catered above all for the education of the young. Each member spent himself for the Society and the Church. Jesuits secretly carried consolation and religious rites to the proscribed Catholics of Elizabethan England. Ultimately they won or kept all South Germany for Catholicism.

The Struggle between England and Spain.—The battle of the two religions is the main motive in the history of the second half of the sixteenth century. It was the avowed cause of the hostility between England and Spain, but there was added to this rivalry on the sea and in the New World.

That wonderful outburst of energy which had made the Spaniards the leaders in the new exploring movement had given them possession of practically the whole of South America, and the English sailors who were waking up to adventure in the early days of Elizabeth felt that they had been taken unawares.

When the Spaniards defended their monopoly of trade to South America the English made reprisals by what was really open piracy on the high seas, and seized the treasure from Spanish ships sailing homeward from Mexico and Peru.

The Spaniards adopted the plan of assembling all such ships in the mouth of the Plata River, so that they might sail together for mutual defence. The prey was but the more tempting, and English attacks on the "Plate Fleet" became a regular feature of the period.

The tales of the sufferings at the hands of the Inquisition of English sailors who were taken prisoners served to fan resentment in England. But Elizabeth held her hand.

She would not send help to the Low Countries struggling for their liberties, but some of the bravest and best of the Elizabethan courtiers and soldiers like Sir Philip Sidney went as volunteers to fight for liberty and Protestantism in the Netherlands.

The purity, nobility, and high aims of many of the great Elizabethans have passed into a proverb, but there is a psychological incongruity between them, and an age in which Elizabeth, the astute Catherine of Medici, the Queen Regent of France, and the good-tempered but cynical Henry IV of France controlled the fate of nations. The explanation would seem to be that these others were dreamers full of the real enthusiasms which the cynical rulers manipulated to further their schemes. After all these Protestant Englishmen had more in common with their arch enemy Philip than with their own queen, whose real personality they were ill acquainted with, for to them she was the Gloriana of Spenser's poetry, the virgin queen, a centre for their loyalty and high religious aim.

The Southern Netherlands were fighting only for political liberty. They were Catholic in feeling, while the Northern provinces were Protestant. Philip had begun his reign by trying to stamp out the liberties of the Netherlands. His instrument was the Duke of Alva, whose cruelty and relentlessness were a byword in Europe. Finally these Catholic provinces remained to Spain with their liberties guaranteed, but the Northern provinces broke away and became the Dutch Republic.

The Armada.—But before this the tacit struggle between England and Spain had become open and declared, and the "Invincible Armada" of great warships fitted out by Philip had been shattered in 1588 by the superior seamanship of the lower lying vessels of the English fleet and by adverse winds in the Channel. An event which had precipitated the Armada fight was the execution in 1587 of Mary Queen of Scots, who had fled to England from her rebellious Protestant subjects nineteen years before, and been kept a prisoner ever since.

Mary was looked upon by the Catholics as the legitimate Queen of England, for they could not consistently acknowledge the right of the daughter of Anne Boleyn. In point of fact many Catholics were content to recognize the *status quo*, but the more zealous and those who were driven to desperation by the wearing persecutions of which not the least detestable were the fines for recusancy, which threatened to impoverish many of the best English families, naturally longed for a new regime, and looked to the romantic and beautiful Queen of Scots as a centre for their hopes.

The condition of the Catholics shows as a dark background against the brilliance of Elizabeth's reign. As time went on, and the counter-Reformation gathered strength, the Queen of Scots appeared a real menace, and the Babington Plot gave colour for her trial and condemnation.

The defeat of the Armada was the deathblow of Spain's greatness. Though treasure still poured into her coffers from the Indies she fell from the first rank among nations. From this time too dates England's supremacy on the seas, and simultaneously the high-water mark of Elizabethan brilliance is reached. The great plays of Shakespeare were the literature appropriate to the period.

Elizabeth refused the urging of Englishmen to pursue her victory to the complete destruction of Spain. She was anxious to balance Spain against the power of France.

The Wars of Religion in France.—France had been the prey of faction all through the century. Since the death of Henry II in 1559 Catherine de Medici, his widow, had really ruled the country for her weakly sons who succeeded each other rapidly. The eldest of them, Francis II, was the first husband of Mary Queen of Scots, and it was soon after his death in 1560 that she returned to Scotland.

The fight between the Reformation and counter-Reformation took the form of civil war in France. Although Protestantism had been severely repressed by Francis I, the contemporary and rival of Henry VIII, and by Henry II, many of the nobles were Hugue-

nots. At their head was Admiral Coligny, the chief of the Navarre branch of the French royal family, and next in succession to the throne after the sons of Henry II, who were all childless. They naturally had a strong Huguenot following. Opposed to them was the ultra-Catholic party led by the family of the Guises, always working in the interests of Spain, for the domination of French politics was one of the many dreams of Philip II to be shattered like the rest.

Catherine de Medici steered for the most part a middle course between the two. But in her foreign policy, because of her dread of Spain, Catherine leaned to the support of Protestants. For religion made very little difference in the relations between states. It was only used as a pawn in the game. The Catholic powers of France and Spain were intensely jealous of each other, and Catholic France frequently helped Protestants abroad.

The period saw two wars of religion in France ending with truces giving some measure of toleration to the Huguenots. But Catherine's passion was the maintenance of her own power, and she discovered with terror a leaning to the Protestants in her son Charles IV. She determined to aim a deadly blow at the Huguenots. The result was the Massacre of St. Bartholomew in 1572, when the thousands of Protestants in Paris for the celebration of the marriage of the Huguenot Henry of Navarre to Catherine's own daughter were struck down on all sides. Henry of Navarre was spared, but the Admiral was slain.

Massacres of Huguenots followed throughout France, but Catherine was a little cowed by the force of Protestant opinion against her, and three years after the massacre some degree of toleration was again granted to the Huguenots.

When Catherine's son, Francis of Anjou, died in 1594, Henry III alone was left, and Henry of Navarre was his obvious successor. But his religion stood in his way, and the Guises fought hard to keep him from being recognized as heir. Henry of Guise dominated the unwilling Henry III, and the War of the Three Henries was fought. Henry of Guise and the king were assassinated in turn.

The Catholic "League" tried hard to prevent the succession of Henry of Navarre, but his conversion to Catholicism, purely a matter of calculation, cleared his way to the throne. He became king as Henry IV of France in 1598, and soon after issued the Edict of Nantes, granting toleration and some measure of political independence to the Huguenots.

A genial if somewhat cynical ruler, Henry IV, always on the basis of absolutism, began many reforms in France. He strove to organize finance and stimulate commerce and adventure, but his time was short. He was struck down by the hand of a fanatic in 1609 as he was about to lead an army into Germany to interfere, always with the idea of the aggrandizement of France, in a civil war of religion which was threatening there.

The Thirty Years' War in Germany was a belated war of religion, but even in Germany the real motive was political, and for Europe at large the war became a focus for political rivalries and ambitions.

The seventeenth century has a different interest from the sixteenth. It saw less vital changes, and was rather a period of settlement and readjustment.

The change is perhaps best emphasized in England where, with the death of Elizabeth and the accession of James VI of Scotland as James I of England, the texture of English history seems to change. In England as in other countries religion and religious differences still form a powerful motive, but the constitutional problem looms larger. England was the only country which passed through a constitutional crisis at the period, but elsewhere too political activity swamped the concentration on religious problems which had marked the period of the Reformation.

THE SEVENTEENTH CENTURY

The seventeenth century reaped much of the fruition of the Renaissance movement. It is much more modern in tone than the sixteenth century, less fantastical, more sober, much further removed from the Middle Ages. Charles I of England, the century's "tyrant," is very different from Henry VIII, a typical tyrant of the sixteenth century. In England the Raleighs and Sidneys, with their peculiarly Elizabethan air of adventure and poetry, are replaced by the Cromwells, Pyms, and Hampdens, men with equally high but changed ideals, and the change is but typical of a transition which affected life in Europe generally. The Thirty Years' War, which focuses the attention and activities of the chief European nations in the first half of the century, is mediæval and lurid enough in its details, but it has a somewhat different character from the religious wars of the previous century. It becomes a centre for a larger and more cynical diplomacy.

In Germany the Emperor Charles V had spent a long life in trying to reconcile the reforming movement with the Church, but had been obliged to accept a *modus vivendi* which gave each prince substantially the power to control religion in his own state. By the Peace of Augsburg in 1555 the Lutheran princes in Germany had the possession of their states confirmed to them, but a clause provided that future converts to the reformed religion must give up their states, and no consideration of the position of Calvinists entered in.

This resignation by later converts to either branch of the reformed religion never in effect took place, and at the beginning of the seventeenth century Germany bristled with problems arising from this cause. Substantially the North of Germany was Protestant while the Southern States had retained or been won back to Catholicism.

The accession to the Empire in 1619 of Ferdinand of Styria, a pupil of the Jesuits and a typical product of the counter-Reformation, was the signal for a new trial of strength between the arrayed forces of Catholic and Protestant Germany. Previous emperors had automatically succeeded to the thrones of Hungary and Bohemia as well as their Austrian dominions, and Ferdinand had already been recognized as heir to the throne by the Bohemians. But Bohemia was Protestant, and the actual accession of so ultra-Catholic a ruler alarmed them, and, declaring that the succession to the Bohemian throne was strictly elective, they now repudiated Ferdinand, choosing in his stead Frederick the Elector Palatine. The Elector was a Protestant, and as the Crown of Bohemia carried with it a vote in the election of the Emperor, a preponderance would thus have been given to the Protestant votes. The Catholic princes ranged themselves on the side of the Emperor and the Thirty Years' War began.

The Thirty Years' War.—It lasted with intervals from 1618 to 1648. The Lutheran princes stood aside at first, because Frederick was a Calvinist and because too the Emperor rewarded them for their neutrality. But the struggle between the Emperor and the Elector ended with the complete defeat of Frederick in the Battle of the White Hill at Prague. He lost not only Bohemia but the Palatinate as well. Spanish troops had poured in to help the Catholics, and it was the fear of the undue advance of the Hapsburg power which led France to go to the help of the German Protestants. The Lutheran princes were roused too, alarmed at the repressive policy adopted by the Emperor in the conquered territories. Outside European powers were involved from various causes. Protestant Sweden was a natural partisan of the Lutherans by reason of its aggressive Protestantism and a natural enemy of Catholic Poland because Sigismund, King of Poland, had been deposed from the throne of Sweden for his Catholicism. Poland was a natural ally of the Catholic Emperor.

Protestant Denmark too was involved by reason of Holstein, which it held as a fief of the Empire.

Russia, a Slavic nation, after its long mediæval subjection to the Mongols had taken on an Asiatic character. But Russia too had had a sort of Renaissance of its own, when it threw off the Mongol domination in 1462, and from this time Russia began to look westwards. Her religion was and has remained that of the Orthodox Greek Church, but it was political and not religious considerations which involved her too in the Thirty Years' War. In the sixteenth century Russia had won her way to the Caspian Sea, and she was anxious now to win a Baltic coast. Here she was baulked by both Sweden and Poland.

The Thirty Years' War is a curious record of bloodshed and passionate strife with curiously little result.

It is divided into periods according to the predominance of some one opposing power. There was the Danish period in which Christian of Denmark was defeated by the Imperial armies under Tilly and by the brilliant Bohemian adventurer Wallenstein.

France under the great Cardinal Richelieu, the regent for the young King Louis XIII, who had succeeded Henry IV, contented itself with the weapons of diplomacy. It was Richelieu who manœuvred a peace between Sweden and Poland and so set Gustavus Adolphus, the hero of Swedish Protestantism, free to champion the Lutheran princes in what is known as the Swedish period of the war. Wallenstein, who had become the leading figure in Germany, was full of dreams of a revived and all-powerful Empire. The religious question was indifferent to him, but Ferdinand saw things quite otherwise, and in 1629 the Edict of Restitution by which all bishoprics lost to the Church in the last seventy years were to be restored, stimulated alike the wrath of the German Protestants and the zeal of Gustavus Adolphus. Wallenstein had fallen into disgrace when the Swedish king started on a victorious advance through Northern Germany, but the Empire's need brought his recall. It was a duel of giants, but it ended with the death of Gustavus Adolphus on the field of Lützen in 1633. A year later Wallenstein was murdered and the war degenerated into a confused series of struggles, with the Swedes fighting for their own hand and France ever fomenting hostilities for the weakening of the Empire.

The Peace of Westphalia, as the series of treaties which ended the war in 1648 are called, marked the death of the Empire's larger hopes. The German states had become independent with a nominal allegiance to Austria, which, with the kingdoms of Hungary and Bohemia, stands out as a great European power by reason of the extent of its territory, and not because of its claims to Empire. France had been growing steadily stronger, taking on a military character, so that it is she and not the Hapsburg power which becomes a menace to Europe in the next period.

The religious question remained much as it was before the thirty years of warfare, of which it was the ostensible motive, but the privileges given to the Lutherans by the Peace of Augs-

burg were now extended to the Calvinists, and there was a character of finality about them which the earlier settlement had not possessed. The son of Frederick the Elector Palatine got back the Lower Palatinate while the Upper Palatinate went to Bavaria. Some German princes gained, others lost, territory as the net result of the war, but to Germany it was all loss. The land had been laid waste and half the population stamped out. Other peoples, and especially France, had made capital out of her sorrow. Meanwhile England, isolated from the politics of Europe, had been passing through the sharpest crisis in its history.

The Constitutional Crisis in Seventeenth-Century England.—On the death of Queen Elizabeth in 1603 the crowns of England and Scotland were united in the person of James VI of Scotland and I of England, the only child of Mary, Queen of Scots. With his accession a new period seems to begin in English history, though the last few years of Elizabeth's reign had already taken on something of the colour of the new time. There had been in these years a kind of pause. Many classes of Englishmen desired change but had waited with a sort of courtesy until the Queen's death. Religion and politics were both ripe for readjustment. At Elizabeth's death there were roughly three phases of religious thought and feeling in England though with endless subdivision. There were the Anglicans, of whom a large class, with a rebound from the aggression of the Reformation, were looking with regret to the lost ceremonialism of mediæval times. There were the Puritans, with their passionate dislike for form and their insistence on the all importance of spirit in religion, and there were the Catholics, a persecuted and proscribed minority clinging to every detail of Catholicism. Each of these classes hoped much from the new reign. The Puritans, who had been ruthlessly persecuted in the latter part of Elizabeth's reign, dwelt on the fact that James had been brought up in Presbyterian Scotland. The Catholics remembered that he was the son of the martyred Queen of Scots, but it was in Anglicanism that James found the most congenial form of Faith. To the disappointed Puritans at the Hampton Court Conference he reiterated his clinching argument that "No Bishop" meant "No King," and in these words lay the kernel of the century's history in England. The Catholics were almost equally disappointed, and the more desperate gave expression to their chagrin in the "Gunpowder Plot" of 1605.

Fixed in his ideas about religion, James had equally unwavering notions of the functions of kingship. From the first there was friction between him and his parliaments mainly on the question of foreign policy. On this James brought to bear all the force of his subtle but unpractical mind, and only succeeded in alienating his people and depreciating England in the eyes of foreigners.

But apart from James's fatuity Parliament had been very much on the defensive from the first, and had in so many words warned the King that much that had been tolerated under Elizabeth in the relations of Crown and Parliament must now be changed.

The English Parliament.—The history of the English Parliament since its beginnings under Edward I had been very chequered. In the fourteenth century the House of Commons, consisting of the knights of the shire and burgesses chosen by the shires and towns, had secured the control of taxation and an approximation to the power of lawmaking in its "petitions" which, if they received the consent of the King and the Lords, became *Statutes* or *Acts of Parliament*. The King had to put the question of war or peace to Parliament, and even the opposition of the nobles to the King had to find expression through Parliament.

With the accession of Henry IV with a parliamentary title and through the greater part of the fifteenth century Parliament claimed to control the King's action more and more. In an age which needed, above all things, a strong executive this excessive control merely hampered the royal policy. Still the fact that the Lancastrian parliaments won for themselves the supervision of the nomination of the King's Council, the appropriation of supplies, and the audit of accounts furnished valuable precedents at a later day when Parliament was really ripe for government.

The Yorkist kings found themselves in a position almost to ignore Parliament, and with the destruction of the old nobility in the Wars of the Roses a new spirit enters in. The Tudor despotism used parliaments as a mere tool. The new nobility, lay and ecclesiastical, under Henry VIII were the creatures of the new dynasty, and this discounted the opposition of the Lords. The Commons, like the classes they represented, were consciously or unconsciously glad of peace at any price. Still the Tudors kept all the forms of parliamentary rule. There was no browbeating, and the King's will became law through Acts of Parliament. During the last few years of Elizabeth's reign there had been signs of restiveness which presaged a new time. Even from the death of Henry there had been a more critical spirit towards Government proposals, and under Elizabeth Parliament had shown sufficient initiative to introduce important bills and offer advice on subjects of public interest in spite of the Queen's assurance to them that it was their business only to say "aye" or "no." When in its last session Elizabeth's last Parliament protested against certain monopolies granted to the Queen's favourites, she immediately and gracefully bowed to their will.

The Tudors were practical, and their very coarseness of fibre procured and preserved their popularity. The Stuarts, in reality less grossly tyrannical, offended by their very idealism. Their attitude is illustrated by their constant emphasis of the "divine right" of kings, by which they meant not the Tudor theory of the divine right of the King *de facto*, but the hereditary fore-ordained right of the legitimate king. James's view that the Parliament existed by grace of the King was met by the hot retort that their rights were "of right and not of privilege." In a controversy of this kind endless precedent may be quoted to support either point of view. In the wordy war under James and the sterner struggle later Parliament continually demanded that the King should show statutory support of his claims. This was impossible in an unwritten constitution.

James had a keen eye for legal points and stretched his claims to the uttermost, as when he largely extended the customs by the "impositions" against which the Parliament protested but which the judges pronounced legal.

Charles I reaped results from his fathers' unpopularity. Parliament, now very much on the defensive, granted Charles at the beginning of his reign tonnage and poundage for one year only instead of for life, as had long been the custom. Charles declared that by non-user the right of Parliament to limit the grant thus had lapsed, and levied the ordinary customs in defiance of Parliament. Five knights were sent to prison for refusal to pay, a fact which led to the passing of the *Petition of Right* in 1628 to be followed only by a new breach in 1629, after which Charles ruled without a Parliament for eleven years.

Meanwhile the religious situation became acute. The Petition of Right had declaimed against innovations in religion, by which was meant the mediæval ceremonialism of the Arminian school of which Charles's friend, Laud, Archbishop of Canterbury, was the chief exponent. Not content with imposing his views on the English Church, Laud tried to force a new prayer book very similar to the English Prayer Book on the Scots. This was deeply resented, and the Scots took up arms against the English King.

The ordinary royal revenue, the King's "own," had never proved adequate to the royal expenses in time of war. With strict economy and straining law and precedent to the uttermost, Charles had been able during eleven years of peace to dispense with parliamentary grants, but the "Bishops' Wars" forced him at last to call a Parliament, the "Short Parliament" as it was called, for, refusing to grant supplies until grievances were redressed, it was almost immediately dissolved. But things were at a deadlock, and by the advice of his friend and chief minister Wentworth, Earl of Strafford, Charles called the famous "Long Parliament," during whose chequered sessions the duel between King and Parliament was fought out.

The Long Parliament.—The Long Parliament attacked every detail of Charles's administration. It impeached Strafford and Laud, and executed first the one and then the other. The Puritan element in the Parliament had become furiously adverse to every conservative element in religion and politics. They passed a triennial act by which Parliament was to be called at least every three years, and the existing parliament was not to be dissolved without its own consent. The Puritans designed to render the King a mere figure-head and to reform the Church in a Puritan sense.

So far they had had a free hand, but in May 1641 the *Root and Branch Bill*, which designed to abolish Episcopacy in the English Church, gave the King a party. Outraged conservatism became ostentatious loyalty. The partisans of the King were not in favour of tyranny, but they were averse from the radicalism of the Puritans. They formed a Constitutional Royalist party. On August 22, 1642, Charles set up his standard at Nottingham, and the "Great Civil War" began. It ended with the execution of the King on January 30, 1649.

At length the Puritan policy had its chance, but the difficulties of revolutionary constitution-making received piquant illustration in the career of the arch Puritan, Oliver Cromwell. He called parliament after parliament, only to dissolve them when they showed signs of that spirit of independence which had been the battle-cry of the party, with the impatience of the strong man for inefficiency he overruled opposition and governed—a completer tyrant than ever Charles had been. Like all such tyrannies, it passed with the tyrant, and but a few months after Cromwell's death England eagerly restored the son of the martyred King. Charles II entered London in triumph on May 29, 1660, and so began the period of the Restoration.

The parliaments of the Restoration were more violently Royalist than the Crown itself. The genial, cynical, and pleasure-loving Charles II was ostensibly as facile a ruler as any parliament could desire, but the parliaments of these days desired only the triumph of Church and King. The Puritans became a proscribed and peculiar people. The Puritan element was relentlessly excluded from the Church, and a strict line was henceforth drawn between Anglicans and "Non-Conformists."

Yet Charles, the most popular of all the Stuarts, was by no means in sympathy with Anglicanism. He was by conviction a Catholic, and had a real desire to see the lot of the Catholics in England improved. He had no animus against the Dissenters, and was prepared

to extend toleration to them as the price of Catholic Emancipation. To this end he plotted with the French King, Louis XIV, whose aim was to make himself arbitrator of Europe. The aggressions of Louis XIV were a menace to England as to other European countries, but Charles's policy was never one of patriotism.

Fortified by a secret treaty with Louis in 1670, Charles two years later issued a Declaration of Indulgence to Catholics and Dissenters alike. But he had to bow before the storm which met it, and it was revoked. Some inkling of the King's plans for a Catholic Restoration made possible the panic retaliations consequent on the spurious "Titus Oates" Plot. Charles spent the rest of his reign in calmly manœuvring against the angry parliaments, who would have excluded his brother and heir, James, Duke of York, from the throne. He manœuvred so well that the Whigs, as the Exclusionist opposition were called, fell entirely into disrepute, and for the last four years of his reign Charles ruled without Parliament, but with the entire sympathy of the Tories and the Church.

His reign, in spite of the furious loyalty of its commencement, shows that the relations between Crown and Parliament were in a state of tension. The struggle had yet to be settled.

The English Revolution.—The character of James, Duke of York, who ascended the throne of England on the death of Charles in February 1685, was the determining factor in the nature of that settlement. James was avowedly a rigid Catholic. During the three years of his reign in England his main object was the promotion of the welfare of his co-religionists. With this aim in view he claimed to override the accepted laws of the land by a free use of the "suspending" and "dispensing" powers. In the first year of his reign James dismissed parliament for refusing to repeal the *Test Act.* The next parliament which met was the "Convention Parliament," which met after the birth of a son to James had led representatives of almost every party in the State to invite William of Orange, the husband of James's daughter Mary, to come over from Holland and protect the liberties of England. James had fled to France, and the Convention declared that he had abdicated. William of Orange became William III and with Mary joint ruler of England.

With the accession of a ruler chosen thus, the parliamentary victory was assured. William III's chief aim, as we shall see, was the fighting out of his life duel with France. He chiefly valued England as a source from which to get money for the fight. As always, Parliament found its chief strength in its control of taxation.

The eighteenth century merely worked out in detail the parliamentary victory won by the Revolution of 1688. The weakness of Anne, the sister of Mary, who succeeded William in 1702, put no check on Parliament. The foreign character of the first two Georges, who did not even attend, for lack of English, the Cabinet meetings, gave over to Parliament control of the executive as well as the monopoly of legislation already won. The royal veto disappeared, and the party system and Cabinet government were developed. George III, "born and bred a Briton," tried once more to override Parliament, and, in the words of his mother's exhortation, "be a king," but he had to bow in the end to forces too strong for him, and his attempt is but an interlude in the steady development of parliamentary government which must, however, be distinguished from "democracy." Democratic government in England was not achieved until the nineteenth century. It has seemed well to sketch the developments ahead, which were the result of the constitutional struggle of the seventeenth century, but other aspects of that period must be briefly indicated. Intimately connected with the religious and political movements of the time, the seventeenth century saw on the part of Englishmen a vast impulse to expansion. This led to the beginnings of that stream of colonization which has since been a so romantic and significant feature of England's history.

English Colonization in the Seventeenth Century.—Elizabethan adventurers had awakened somewhat later than the Spanish and Portuguese pioneers to the marvellous possibilities of profit and adventure in the newly-discovered portions of the world. They soon outdistanced their predecessors in daring and endurance, from the brave seekers after a North-West Passage to the explorers of the Pacific Ocean and the deserts of Central Asia. But the one project of actual colonization, Raleigh's plantation of Virginia, was a failure. The difficulties seemed insurmountable, although France and Spain had both already made successful colonies overseas.

But with the beginning of the seventeenth century a determined series of efforts planted English colonies along the Eastern coast of North America. Virginia, successfully planted at last, became the home of aristocratic landowners, loyally Anglican in religion, and working their immense rice and tobacco plantations with the labour of the negro slaves, who had been imported in large numbers from Africa, since Sir John Hawkins had conceived the brilliant but brutal idea of their transportation.

The success of the Virginia plantation led to a long series of successful colonial enterprises. Far to the north of Virginia rose the group of "New England" colonies, the first of which was Plymouth, founded by the "Pilgrim Fathers" in 1620. But as Puritanism too had its shades, and these would not tolerate dissent, other groups of Puritans formed new colonies near, the greatest of which was the "Inde-

pendent" colony of Massachusetts, in which no man might stay unless he belonged to an "Independent" church. The little colony of Rhode Island alone granted toleration to all sects. These Northern colonies were different in character from Virginia. The soil was less fertile and demanded more labour, but the climate allowed of the use of white labour. At first Plymouth had declared for a socialistic arrangement, but here as elsewhere each man soon built himself a house and claimed appropriate lands, and the population consisted mainly of farmers. They were a hard-headed, thrifty, and stern people. They did not use negro labour to any great extent, because they had little use for it, but they stamped out the native Indians without pity. Their idealism showed itself in a zeal for education, which led to the early foundation of such centres of learning as the John Harvard College near Boston.

By conquest or by settlement England had won thirteen colonies on the Eastern coast of North America by the end of the seventeenth century. Lord Baltimore had founded in 1632 a proprietary colony where toleration was given to Catholics, who formed the bulk of the population. It was called Maryland. The Quakers found peace in Pennsylvania, founded by William Penn in 1682. The Carolinas had been planted out twenty years before. These Southern colonies resembled Virginia in their aristocratic character. Between them and the democratic North, and resembling the North in character, were the New Netherlands, won from the Dutch and resolved by the conquerors into New York and New East and New West Jersey. The winning of these colonies in 1667 leads us to consider what had been the relations between England and the other countries of Europe during this period.

The Struggle for Sea Power.—During the period of the Civil War in England she had very little part in European politics, but during the Commonwealth Cromwell by a vigorous foreign policy increased the nation's prestige in the eyes of Europe. He favoured France in opposition to Spain, for though Spain was rapidly on the decline the tradition that she was formidable remained, and to Cromwell she was still the symbol of Catholic aggression. By his policy Cromwell helped to increase unduly the power of France.

The little republic of Holland, formally recognized as such by the Treaty of Westphalia, looms large in this period. She had preceded the other nations in setting up trading stations on the coast of India and in the Eastern seas, but they had been speedily imitated by both France and England. There was keen rivalry in these parts, and after a fight between the English and Dutch at the "Massacre of Amboyna" in 1623, the English abandoned the East Indian islands, but soon after English settlements were made at Calcutta, Madras, and Bombay, which afterwards became the centres of the three great Presidencies of the British Empire in India. Holland took rank at this time as a first-class power, a position which she had won by way of accident and to which her size did not entitle her. She had practically secured the monopoly of the carrying trade of the world, but the *Navigation Act*, passed under Cromwell in 1651, crippled her monopoly for ever. For the future goods carried into England or any of its colonies must be brought by English ships, or ships belonging to the country from which the goods came. The Dutch fought hard against this provision. Under Cromwell, as again under Charles II, the great generals on both sides were almost equally matched (for the Commonwealth had revived the English fleet as well as the army), but in the end the Dutch had to give way on the subject of their carrying trade, and incidentally lost the New Netherlands as well.

After this France became England's chief rival in America and on the seas. Canada had long been claimed by the French, who had colonized it to the east as England had done the coast further south. France had also colonized Louisiana, and towards the end of the century a plan was formed to unite this with Canada by a chain of posts along the Mississippi. This would have meant the prevention of the expansion of England's North American colonies westwards. England had other grievances against France at this time, when France had so dominated Europe that this period of European history is generally labelled the "Age of Louis XIV."

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The Age of Louis XIV.—Louis XIV ascended the French throne in 1643 and reigned until 1715. He was a man of some ability and vast ambition, and he had good material to build upon in the work for the strengthening of France, which had been achieved successively by the two great ministers, Cardinals Richelieu and Mazarin.

Louis' first minister was Colbert, and under him France made the only great efforts she has ever made towards colonization and development of sea power. Trading companies were formed as in England and Holland, but these were not given a free hand, having to work under State supervision. For the first time too France had a considerable navy.

But it was in Europe itself that the ambitions of Louis really lay. The army was increased and scientifically trained. For years Spain was ruled by a sickly boy without heirs, whom all expected to die at any moment. Louis, who had married a Spanish Infanta, was ever seeking gain from the arrangements about the "Spanish Succession." He saw in time that he would never secure Spain, but all through his reign he was making new claims, his object being to extend the boundary of France to the Rhine

on the east and to absorb the Spanish Netherlands.

Once established in the Netherlands, France would have been an incalculable menace to Holland, and William of Orange became the recognized champion of Europe against Louis.

Time after time Louis defeated the Dutch, but it was the genius of the stubborn stadtholder that the minimum of gain resulted to France from those victories. The story of the heroic Dutch resistance is writ large in history.

When William became King of England she was inevitably involved. Louis roused English hostility by his promise to the dying James II to push the claims of his son to the English throne. So it was that even after William's death England stood in the forefront of Europe's struggle with France; for all Europe was thoroughly alarmed by this time. The genius of the great English general, the Duke of Marlborough, wrested from France the results of half a century's battles.

Peace was at last signed in the Treaty of Utrecht in 1713, and bounds were set for nearly a century to French aggression. The danger of France and Spain being united under one ruler was averted. The Spanish Netherlands, fettered by Dutch "barrier fortresses" against France, went to Austria. England won a foothold in the Mediterranean by the acquisition of Gibraltar and Minorca, and France yielded up to her in America Newfoundland, Nova Scotia, and the Hudson Bay Territory.

In spite of his failure, France under Louis XIV had dominated Europe morally. She had set the standard in manners and literature. It was the age of France's greatest writers and most famous preachers, and the European courts, even the Russian court emerging from barbarism under Peter the Great, took the French court as its model.

Yet Louis had offended opinion everywhere by his merciless treatment of the Huguenots, the peaceful and thrifty Protestants of Southern France. After the Revocation of the Edict of Nantes many of these were killed and many more fled, so depriving France of a valuable commercial element in its population.

France was to pay later for this, and still more for the financial drain which the magnitude of the wars had made on her resources. The Treaty of Utrecht marks the real end of the seventeenth century.

THE EIGHTEENTH CENTURY

The eighteenth century has a character peculiar to itself. It was an age of classicism in literature and cynicism in politics. The religious motive sank into the background everywhere. The sects had taken final form. There was still persecution and proscription, but the grievances of proscribed sects, as of the Catholics in England, arose from penal laws already in force and not from any new initiative against them. There was indeed a new spirit of toleration growing up, arising mainly from indifference. In England as elsewhere there were classes who tended to despise all dogma and hold loosely to a vague Deism. Before the end of the century, and especially in France, a class of confessed atheists had grown up.

The mass of people in England as elsewhere, though not irreligious, were not enthusiastic. Religion ceased to be the main preoccupation of great masses of men, as it had been in the sixteenth century and remained largely in the seventeenth.

In England the frivolity among the upper classes, which had marked the rebound from Puritanism at the Restoration, became the prevalent tone of society. Even ripe scholars in eighteenth-century England were hard drinkers and keen gamblers. The periwigs and crinolines, which are distinctive features of the period, seem to symbolize aptly enough the tone of the age, its suavity and leisureliness, its unemotional preoccupation with trifles.

The cynicism of eighteenth-century politics is best seen in the motives and conduct of the successive European wars which fill the period, wars important not only from a European point of view but because they determined to England possession of India and North America.

The War of the Spanish Succession (1740-1748), in which the great European powers formed into two camps for or against the Empress Maria Theresa, the first woman to rule Austria in her own right, left the relations of the powers much as they stood at the beginning. It decided only that Maria Theresa should keep Austria, and gave the Austrian province of Silesia to the new little kingdom of Prussia, into which the Electorate of Brandenburg had been developed by a succession of able rulers. Frederick the Great of Prussia divides with Catherine of Russia the reproach of the supremest disregard for any motive but their own profit.

In the "Seven Years' War" (1756–1763) there was a remarshalling of forces. England fought on the side of Prussia against France and Austria. Maria Theresa was bent on recovering Silesia, and the colonial rivalry of England and France made them inevitable enemies. It was while the European war was taking its course in Germany that a few men of genius won Canada and India for England. But it is easy to exaggerate the part played by a Wolfe or a Clive. In point of fact, there were already more English colonists in Canada than there were French, and as India could be won only by the landing of European troops the power which had the command of the sea had an irresistible advantage. The great French-

man Dupleix, so keen to win India for France, never had the chance which came to Clive.

The Fight for India.—The Portuguese had, after their discovery of a new route to India in the fifteenth century, tried to monopolize its trade, but the Dutch soon began to trade with the towns on the east coast, and before long France and England both set up trading stations in India too. The chief English stations were Calcutta and Madras on the east coast and Bombay on the west. The chief French station was Pondicherry, south of Madras. It was Dupleix, the Governor of Madras, who first realized how easy it would be for a European power to win India for itself.

India had in it every element of disunion. The north belonged largely to the Aryan race, which had poured into India at the time that another branch was journeying to Canaan.

There were traces too of the Dravidians, a negro race which they had conquered, and these prevailed in the south over the Aryan element. After the brilliant but unsubstantial victories of Alexander the Great India suffered no invasion for many years. Then successive Mohammedan hordes poured in to conquer, so that there are more Mohammedans than there are Hindus in India to-day.

In the early part of the sixteenth century a band of Mongolians from Central Asia invaded India, and the "Great Mogul" set up his capital at Delhi. After two centuries of splendour the Mogul Empire broke up. The viceroys of the Emperor everywhere became independent princes, and there was no longer any sort of unity.

Such was the state of affairs when England and France made India a battleground in the wars of the eighteenth century.

The genius of Clive and the superiority in sea power of England over France determined the struggle, and India was won for the English.

At the end of the "Seven Years' War" France had no foothold in North America or India. The East India Company was given the practical control of British interests in India. Hardly had England won these enormous accessions to her Empire when she lost, for good and all, her original North American colonies.

The War of American Independence.—The eighteenth-century theory of colonies granted them very little independence of the mother country. In point of fact, the North American colonies had a large degree of self-government through their legislative assemblies. These were subject through their governors to the English Crown, but naturally had complete freedom in local affairs. But England had rigidly assumed from the beginning the right to regulate the trade of her colonies. Her regulations had been skilfully evaded by a vast system of smuggling, but the right had never been denied. The expenses of the European wars, which had been largely financed by England, led to an attempt in 1765 to impose a "Stamp Act" on the Americans, which was in the nature of direct taxation. Indignation led to its withdrawal, but George III and his ministers, having lost the profit, were determined to save the principle, and imposed an irritating tax on tea, which was not even a source of gain to the mother country.

The result was a complete breach. The "War of American Independence" ended in the recognition of the independence of the United States of America in 1783. The new nation was a federal republic under a president. Gradually new colonists pushed their way westward until to-day the republic stretches from sea to sea. Every year thousands of emigrants from every country in Europe pour into the "States," to become Americanized in language and mode of life in a marvellously short time.

There was really no inevitable reason why this great progressive people should not have remained in the British Empire. The breach was the result of mere blundering. England did not by any means immediately realize that eventually she would have to grant self-government to all her colonies, but there was never again such a deadlock. For over fifty years longer neither Canada nor any other British colony received any greater degree of self-government than the North American colonies had had before the War of Independence.

But in Canada the French settlers were conciliated in every possible way and the colony never swerved from its loyalty. Numbers of "Loyalists" from the "States" sought a refuge there, and so strengthened the English-speaking element in the population.

The progress of Canada, especially in the last century, has been no less wonderful than that of the United States. It too now stretches from sea to sea, and a vast number of emigrants land yearly on its shores.

In India meanwhile British rule was steadily growing. More and more of the native princes bowed to British sovereignty, while Bengal and the little districts round Madras and Bombay were directly in British hands. The rule of the East India Company, partly through the chances it gave for individual profit, partly through the peculiar difficulties of the situation, proved very oppressive to the natives. The impeachment and trial of Warren Hastings, who had succeeded Clive as Governor of Bengal, revealed a harassing state of affairs. Warren Hastings was acquitted at last, for he had ruled as justly as conditions allowed, but in 1784 a rearrangement was made giving joint control to the East India Company and to ministers of the Crown, an arrangement which lasted until 1858.

The same period which saw, as it were, the making of new nations, saw one of the nations of Europe wiped from the map.

The Partition of Poland.—The partition of Poland has a unique interest, not only by reason of its romantic and tragic appeal, but because it illustrates better than any other event the character of European politics in the eighteenth century.

Russia and Prussia were peculiarly bent at this time on territorial aggrandizement. The Polish province of West Prussia jutted out from the body of the kingdom on to the Baltic, and so divided the two portions of the Prussian kingdom, Brandenburg and Prussia proper. Frederick the Great desired West Prussia as passionately as he had desired Silesia.

The Eastern part of Poland had always been coveted by both Russia and Turkey. The Turks had been driven back from Vienna by the heroic King of Poland, John Sobieski, in 1683, and the first years of the eighteenth century saw an end of their aggression on this part of Eastern Europe. But Russia was still a danger to the Poles.

Poland's peculiar social and political character made it an obvious prey to unscrupulous politicians like Frederick the Great and Catherine of Russia. It was a kingdom, but its king had no power. For any act of government the unanimous consent of the nobles must be obtained. The noble class was exceptionally large in Poland, the only other class being the serfs. Obviously unanimous agreement on any subject occurred but seldom, and the activities of the State were paralysed.

So it was that Russia, Prussia, and Austria on various pretexts were able by successive partitions to divide the lands of Poland between them. Austria joined in the spoil, because she could not afford to allow the nicely adjusted balance in Eastern Europe to be upset as it otherwise would have been.

Individual Polish heroes led forlorn movements against the oppressors, but Poland ceased to be a nation. Polish exiles may be found in every country of Europe waiting and hoping for a day of retribution, which now at least seems at hand.

But before the third and last "partition" in 1795, the eighteenth-century system had received a startling blow in that vast upheaval of forces which have been labelled the "French Revolution."

The French Revolution and the Romantic Revival.—In spite of the eighteenth-century indifference to religion and the general lack of high ideals, the century saw a movement towards political enthusiasms which, by their very intensity, partook of the nature of a religion. These rose to fever heat in France towards the end of the century and brought about the French Revolution, which influenced conditions and events in every country of Europe. The propaganda of the Revolutionary theories and the conservative resistance to them are the dominant notes in history for at least a quarter of a century.

There were all manner of political theories and panaceas rife in the second half of the eighteenth century. The constitutional crisis in England in the seventeenth century had naturally turned the minds of thinkers there to problems connected with the nature of government and the origin of society, and the English philosophers, Hobbes and Locke, had each furnished a theory.

But the eighteenth century was concerned in these problems with a greater ethical interest. There was much speculation on ideal forms of government and discussion of the rights of man, the duties of rulers towards their subjects, and of subjects towards their rulers.

One school of philosophers inclined to hold up benevolent despotism as the ideal form of government. In point of fact, most of the governments of Europe in the eighteenth century were despotisms, benevolent or otherwise. Frederick the Great was in his way a benevolent despot, and his subjects acquiesced in his despotism. The Emperor Joseph, on the other hand, full of schemes for reform to be imposed from above, was met with distrust by his people.

But most political philosophers emphasized the fact that the origin of all government was the will of the people, and insisted on a democratic government as the ideal. It was this theory which became popular among all classes who had leisure and education enough to take any interest at all in politics. Everyone was equally vague as to the actual workings of this ideal democracy. The American revolt against England stimulated political enthusiasms.

But all this vague theorizing and speculation was to concentrate into activity in France. It was through the French Revolution that constitutionalism and democratic principles did at last win their way in Europe, though painfully and with many set-backs. The French Revolution then is the prime factor in modern history.

The French people have a high aptitude for abstract ideas. In the later eighteenth-century discussion about the "Rights of Man" was current coin in the brilliant salons of the highest French society, a society which was to be shattered when the ideas it played with were translated into fact.

The Encyclopædists.—The writers in the great *Encyclopædia*, published in the third quarter of the century, brought a supremely critical spirit to the treatment of all existing institutions. The *Encyclopædia* was edited by Diderot, and had among its contributors the sceptical d'Alembert, and Voltaire, the most iconoclastic spirit of his time. The Encyclopædists indeed were much more critical than they might show themselves in the *Encyclopædia*, and they represented a large and growing school of thought.

The critical spirit might have spent itself on abstractions but for a peculiar conjunction of circumstances which suddenly gave its expression the force and significance of a gospel.

France in the eighteenth century was woefully exhausted by the wars of Louis XIV. Already the exhaustion was felt under his great grandson and successor, the dissipated Louis XV. It was felt still more under the virtuous but mediocre Louis XVI, grandson of Louis XV, who succeeded him in 1765. The country was poor, but the Court was extravagant. The nobles were exempt from all taxation, and so the burden fell on the middle classes and the peasantry. The misery of the French peasantry in the days before the Revolution has often been the subject of exaggeration, as also the degree of their "feudal" dependence on the "seigneurs." There was little or no serfdom in France such as still existed in large tracts of Eastern Europe; still the poor were burdened while the rich went free, and France was threatened with financial ruin.

There is always a tendency in times of discontent to find a panacea for social evils in political reform, and the theorists were now convinced that only representative government could save France. So it was that the States-General, the nearest parallel which France had to the English Parliament, was called and met in May 1789.

The States-General had not met since 1614. There was now immense excitement and hope in France. This was speedily dashed when an order went forth that the three estates—the nobles, clergy, and the "third estate," roughly corresponding to the "Commons" of the English Parliament—should register their votes separately. This meant that the representatives of the privileged classes would inevitably override the third estate. A sharp struggle over this question led to the Commons declaring that they constituted a National Assembly. The members of the other two estates were invited to join them, and a few did.

A royal order to dissolve and the closing of the hall at Versailles, where the representatives had met, was followed by an adjournment to a tennis court near, where the Assembly took the famous oath on June 20 to give France a constitution. So began the French Revolution. The work of giving France a constitution occupied history for many years to come.

In the days which ensued events followed each other rapidly. The National Guard was formed. The Bastille, the frowning Paris prison which had always stood for a symbol of tyranny, was stormed. Those of the nobles who were most alive to the signs of the times hastily left France, and so began that stream of emigration of aristocrats which becomes a feature of the period.

Destructive work the Assembly found easy and performed in abundance. The privileges of clergy and nobility were swept away. But every attempt at constitution-making failed, because the Assembly confounded a strong executive with despotism.

Louis XVI at last tried to escape with his queen and his children from France, but was stopped at Varennes. He was "suspended" for a time, but at length was accepted as the figure-head of the new constitution. The National Assembly was dissolved, and a self-denying ordinance prevented any of its members sitting in the new "Legislative Assembly" which replaced it. Thus France lost the services of the only people with even a limited political experience.

The great bulk of the members of the new Assembly were republicans, and these were divided into the more moderate Girondins and the rabid Jacobins, whose real leaders, Danton, Robespierre, and Marat, were not even members of the Assembly. The republicans took as their gospel the *Contrat Social*, the tract of the famous French-Swiss Jean Jacques Rousseau, whose emotional and sentimental force distinguished him from the more purely destructive and cynical Encyclopædists. Rousseau was above all things a stylist. "Liberty" became a very passion with these men, and the story of the Revolution is witness to the crimes committed in her name.

The War against the Revolution.—Already foreign governments were alarmed at the course of events in France, and Louis XVI and still more his Queen, Marie Antoinette, "the Austrian," as the Paris mob had called her in hatred and derision, were inevitably hoping for rescue from without.

The Emperor of Austria, Leopold, brother of Marie Antoinette, and Frederick William II of Prussia had both made representations to the French Government, but it was the French themselves who finally declared war at the moment when Leopold died and was succeeded by his son Joseph, less zealous in the cause of his aunt.

Many reasons led the French leaders to desire war. The traditions of the country were military, and rulers had always found popularity in victorious warfare.

Again, too, the ancient dream appeared of giving France her "natural" boundaries at the expense of the Germans on the East and the Belgians to the North.

Lastly, there was the element of propaganda, the strong impulse to impose the Revolution and its principles on the other countries of Europe.

The anger and terror which war begets made possible deeds from which, the more rabid leaders assured themselves, there could be no looking back. Europe was aghast at the terrible "September Massacres" of the members of the French aristocracy, who by this time

crowded the prisons. In January 1793 Louis XVI, the "citizen Capet," was beheaded, and inevitably monarchs all over Europe joined the war against Revolutionary France.

France was now frankly a republic, and a new era began from the "Year I" of the Revolution. Contrary to every expectation the French were able to drive back the foreign invaders from their territories. They could not have waged war better if they had been a united nation under a strong government. The common soldiers were fired by patriotism, while the officers knew that failure might be followed by the guillotine under the new Reign of Terror which the government speedily became.

The European powers made the mistake of under-estimating the strength of France. Before long the Rhine Provinces and Belgium were taken by the French.

Meanwhile, after a struggle between the Girondins and the Jacobins, the latter won the day, only soon to become divided against themselves when the less rabid "Indulgents" protested against the measures of the Terrorists. The madman Marat was assassinated by Charlotte Corday. In the district of La Vendée the conservative peasants rose in revolt for Church and King. The revolt was stamped out with the ruthlessness characteristic of the "Terror."

Danton, indifferent to bloodshed if it served his end, but no lover of it, fell in his turn before that system of martial law which was of the essence of the "Terror."

Robespierre, who sacrificed Danton, fell too at last, and with his death the Terror ceased—chiefly because the approval of it by Robespierre, the people's idol, had alone made it possible. Robespierre fell, and the Terror ended in July 1794. The success of the French arms made government by martial law no longer necessary. In the winter of 1794 Holland was overrun and transformed into the "Batavian Republic." Its Stadtholder found a refuge in England, and gave up to her Holland's rights in the Dutch colony at the Cape of Good Hope.

England, in spite of the enthusiasm of French theorists for her constitution, was the consistent enemy of the Revolution throughout.

Napoleon.—On the ruins of Robespierre's government was set up the "Directory." At the elections which were necessary to create a new "National Convention" the services of the young Corsican officer, Napoleon Bonaparte, were enlisted to put down disorder. In the days of the Terror he had won back Toulon when seized by the Royalists. The Directory then was established by military force with the proverbial result. Napoleon Bonaparte, ostensibly but one of the generals of the Republic, was from that hour its military dictator. The struggle between Europe and the Revolution resolves itself into a duel between England and Napoleon.

A man of genius, Napoleon took little notice of orders from Paris, but worked out his campaigns in his own inimitable way. By the end of 1797 Lombardy had been won from the Austrians and part of the Papal States taken from the Pope. The "Cispadane Republic" was set up in North Italy. Austria had to give up Belgium also to France.

Spain had consented to ally herself with France, and the French, Spanish, and Dutch fleets threatened to be more than a match for the English on the sea, but successive victories over the Spanish at Cape St. Vincent and the Dutch at Camperdown guaranteed England's supremacy.

Bonaparte returned to Paris after his Italian campaign and seemed to threaten an invasion of England. But his real objective was Egypt, whose conquest he hoped to make a basis for vast aggressions in the East. He subdued Egypt but was foiled in Syria, and the brilliant victory of the English fleet under Nelson over the French fleet at the mouth of the Nile, on August 1, 1798, cut off his communications with France. Abandoning his plans, Napoleon raced back to Paris to give a garbled account of his prowess.

England was the only power actually at war with France, but a new coalition was forming, for French aggression had completely outraged opinion in Europe. The Pope had been taken prisoner and a Roman republic set up. The monarchy of Naples had been deprived and the "Parthenopean Republic" had taken its place. Switzerland, whose cantons had no desire for close political union, had to be cut to the same pattern, and became the "Helvetic Republic."

When Napoleon got back from Egypt the Abbé Sieyès, who had been now making constitutions for ten years, came forward with another. Subtly planned with a system of checks and counter-checks, it could only result in absolute inefficiency, but with one vital alteration it served perfectly Napoleon's purpose.

All the powers which were so jealously guarded were given over to a "First Consul" who could override every other element in the constitution. Bonaparte became "First Consul," to receive four years later the more accurately descriptive title of "Emperor." It seemed as though France must pass on its way to democracy through a stage of tyranny like the city states of antiquity. Meanwhile the struggle between France and Europe went on.

The Struggle between England and Napoleon.—Great Britain and Austria refused to accept the overtures for peace which Napoleon made to them, and Napoleon turned his arms against the Austrians, defeating them once more in Italy and more decisively at Hohenlinden. Austria was forced into another peace, and Great Britain was once more left alone to fight the French.

The dangerous "Armed Neutrality," which would have denied the right of British ships to search the vessels of neutral powers, was ended once for all by the Battle of the Baltic, after which the Danes, otherwise at peace with Great Britain, had to capitulate on this point. A general peace, which could but be a truce, was signed in 1802.

Meanwhile Napoleon set himself to put order into French affairs. Like many military despots before him, he ruled benevolently. The codification of the law, the reconciliation of Church and State (without the restoration of Church property), and many other measures made for stability, but Napoleon's despotism was certainly not less complete than that of Louis XIV or Louis XVI.

With all the snobbishness of a "new" man, Napoleon tried to found a dynasty with more magnificence and show than had marked the Bourbons. Exiled royalists were encouraged to return to court, and extravagant titles were showered in abundance on the complacent.

A complete reorganization of Germany in the interests of France and the increasingly direct control of the Italian, Swiss, and Dutch republics, constituted a virtual breach of the Peace of Amiens, and in 1803 war was again declared between France and Great Britain. Napoleon prepared a vast army with which he intended to invade England, but the British fleets controlled the seas, and the opportunity never came, and in 1805 a third coalition was formed in which Russia and Austria joined Great Britain.

By a series of brilliant manœuvres the British fleets prevented all chance of the invasion of England, rumours of which had caused almost panic for more than two years. Their successes culminated in the great Battle of Trafalgar, where Nelson, at the cost of his own life, practically annihilated the combined French and Spanish fleets.

Napoleon meanwhile used his army for the brilliant victory over the Austrians at Ulm, followed up by the still more brilliant victory of Austerlitz.

And now the show of republican propaganda was openly abandoned. The conquered lands everywhere were parcelled into kingdoms, and Napoleon's relations and friends set as rulers over them. Already there was a "Kingdom of Italy" which was now enlarged. The "Kingdom of Westphalia" was given to Jerome Bonaparte, and Belgium and Holland formed one kingdom under Louis Bonaparte, another of Napoleon's brothers, while Naples was given to yet a third. As though to emphasize the breach with past history the Emperor of Austria formally resigned the historic title of Holy Roman Emperor. There can be no doubt that Napoleon coveted it, but he never assumed it.

Prussia, now under Frederick William III, had been hitherto complacent towards Napoleon, but was at last alarmed. Napoleon crushed her belated resistance at Jena. The Prussian King's appeal to Russia brought war between Napoleon and the Russians, ending in Napoleon's victory at Friedland. This was followed by a complete change of policy on the part of the Tsar Alexander. Partly impressed by the personality of Napoleon, partly fired by ambition, Alexander at a meeting with Napoleon at Tilsit agreed to a project by which the two should practically divide Europe between them.

Napoleon's first act after this was to try to impose the "Continental System" to ruin British trade. No country was to import goods brought to it in English ships. As England had a practical monopoly of the carrying trade of the world, every country was dependent on the prohibited goods, and the decree was of its nature doomed to failure. But England did not wait for this to be demonstrated. She seized the Danish fleet. Russia had soon withdrawn from the system.

But now a new force enters the struggle. England, perhaps alone of the nations of Europe suffering from Napoleon's aggression, had up to now shown any sense of nationality.

Suddenly at this point a flame of national resentment broke forth, which, in spite of the stupendous efforts to beat it back, consumed in a few years the swollen conquests of France, and drove her back to her original boundaries.

Portugal's refusal to join the Continental System led to the sending of French troops to subdue her. Immediately after, Napoleon took occasion of political troubles in Spain to persuade the Spanish king to abdicate and his son to give up his claims to the succession. Spain was then to be handed over to Napoleon's brother Joseph. Popular feeling in Spain was completely outraged, and Napoleon's armies there found themselves face to face with such a force as they had never before had to reckon with.

The Peninsular War.—The Peninsular War (1808–1813) which resulted gave Great Britain a permanent basis on land against Napoleon. The Spanish officers and regular soldiers were of little use, but the English soldiers were much helped by the guerilla warfare maintained by the peasants against sufficiently small bodies of the enemy's soldiers. The heroic Sir John Moore saved Southern Spain from Napoleon in the first campaign, after which Napoleon withdrew. For five years longer the English, under Wellington, proved more than a match for the various French generals sent against him with their army of a quarter of a million.

Napoleon never realized sufficiently the significance of the Spanish resistance to concentrate on it. He occupied himself once more and successfully against Austria, and then, exasperated at Russia's refusal to maintain the Continental System against the arch-enemy England, the Emperor, whose self-confidence knew

no bounds, got together his "Grand Army" of 400,000 men and marched to subdue Russia in June 1812.

He was for once utterly out of his reckoning. The appalling severity of the Russian winter, which fell before he had crossed the country, decimated his army, and when the survivors, still a vast throng, reached Moscow they found it deserted and in flames.

There was nothing for it but retreat. The Russians would not give battle, but harassed the rear and flanks. Provisions were short, the cold intense. Only a fragment of the vast army returned to tell the tale.

The Russian disaster and the rising spirit of nationalism brought a combination of another calibre than the previous coalitions against Napoleon. His defeat at Leipsic was given the significant name of the "Battle of the Nations."

Even now the Powers, under the influence of the glamour of Napoleon's great genius, would have left him France bounded by the Rhine, the Alps, and the Pyrenees. He refused fatuously, and the allies invaded France.

Advised by his marshals that resistance was but foolishness, the great Emperor abdicated. He was banished to the island of Elba in the Mediterranean, and a Congress of European Powers met to reconstruct the map of Europe.

They quarrelled inevitably, and Napoleon, eating his heart out in Elba, hearing rumours of their dissensions, determined to pit once more his strength against their weakness.

Escaping from Elba, he gathered an immense army in a triumphal march towards Paris. Louis XVIII, the brother of Louis XVI, who had been restored to the French throne, fled. It was in the March of 1814 that Napoleon fled from Elba. By June he was ready to face a coalition, but only the Prussians under Blücher and a mixed army under Wellington were ready to resist him in Belgium. He tried his old tactics of dealing with each division separately, but Blücher came up while the struggle was still undecided between Wellington and Napoleon at Waterloo.

The Prussian reinforcement decided the day, and Napoleon rode from the field defeated.

Shortly afterwards he gave himself up to the English, and was condemned by the Powers to live out the remaining years of his life at St. Helena, from which there could be no escape.

And now the work of remaking Europe was taken up again.

The Remaking of Europe.—The powers proceeded to reconstruct Europe as though the Revolution had never been. The new spirit of nationalism was entirely ignored. Holland and Belgium, in spite of their different traditions, were united as one kingdom under the House of Orange. Prussia's Grand Duchy of Warsaw, taken by Napoleon, was given, under the name of the kingdom of Poland, to Russia. Prussia was given instead half Saxony and a group of Rhine Provinces, which made her boundaries coterminous with France, reduced to her limits of 1789. The German states were formed into a loose confederation with Austria at their head. In Italy, Lombardy and Venetia went to Austria, and Naples was restored to the Bourbons.

The reconstruction and subsequent government were in the spirit of extreme conservatism. The "Holy Alliance" between the Tsar, the Emperor, and the King of Prussia was made with the avowed purpose of resisting revolutionary principles. Reforms were allowed in most of the European states, but by the grace of the monarchs. Serfdom had received a crushing blow, and great masses of serfs were set free. Only in Russia did serfdom remain, and even there it was at last abolished in 1861. The "Charter of Liberties," which Louis XVIII had to grant in France, providing for some degree of self-government by the people, had its parallel in several lesser German states. Reform had spread quickly in Prussia, especially under the influence of the great statesman Stein, but the Prussian King regarded them still with the attitude of the benevolent despot of the eighteenth century.

Yet Revolutionary principles had been sown broadcast. The reaction was but temporary, and only possible because the Revolutionary movement had been merged in the military aggression of the Napoleonic conquests. During the half century after Waterloo nation after nation fought for and won a "charter," and the people everywhere in some sort came into their own at last.

The rise of democracy was fostered and furthered too by the new spirit of nationalism which had had its birth in Spain's resistance to Napoleon. All sorts of new forces were at work to develop the intelligence and the political self-consciousness of the people everywhere, forces which may be roughly labelled the Romantic Revival.

The Romantic Revival.—With the coming in of the nineteenth century Europe and its peoples seem to take on a more modern character. A greater variety and capacity for enthusiasm marks the nineteenth century off from the eighteenth. The new moral atmosphere was, in part at least, the result of great physical and social changes, which affected the European countries and especially Great Britain, in the second half of the eighteenth century and the beginning of the nineteenth, changes which are summed up in the term "Industrial Revolution.'

New discoveries and inventions of machinery, worked first by hand, then by water-power, and lastly by steam-power, revolutionized the conditions of labour. People thronged from the country to work in the new factories set up in the towns, which grew rapidly in size, though not

in proportion to the needs of the workers, who were often miserably housed and fed. Especially sad was the lot of little children who were employed to tend the machinery.

But the congregation in towns made for the spread of ideas, and with remedial legislation, such as the Factory Acts in Great Britain, conditions improved.

The same spirit which eventually made European countries demand a charter led to the reform of the franchise in England in 1832, when the first of several successive "Reform Bills" was passed. The early nineteenth century saw a reaction from the classicism of the eighteenth. In literature men harked back to mediæval ideals, and a new appreciation of nature marked the times.

Men grew religious again. The great Wesleyan movement had alone redeemed the character of eighteenth-century religion. The early nineteenth saw at once an Evangelical revival in the Anglican Church and the High Church revival known as the Oxford Movement. At the same time a new humanitarianism led to the repeal of the penal laws against Catholics in the British Isles. Pitt had won Irish consent to the union of the English and Irish parliaments in 1800 by the bait of complete Catholic Emancipation. The bigotry of George III had prevented the fulfilment of a virtual promise, but the position by which Irish Catholics could vote, but not for a fellow Catholic, was too anomalous to last. The emancipation of Irish Catholics involved that of English and Scottish Catholics too, and, though there was still much "nopopery" agitation, the trend of public opinion was in favour of the Catholic Emancipation Act, passed in 1829.

There was now more variety and ferment in every department of life, more courtesy and true charity in the relationship between men. England had demanded the suppression of the slave trade at the Congress of Vienna, and she led the way in its abolition. When the Civil War on this subject broke out between the North and South in 1861, the United States was alone among civilized countries in maintaining the system of slavery. The Civil War between the "North" and "South" of the United States began when the South threatened secession from the union because of federal interference with slavery. The South naturally clung to an institution with which its chief interests and traditions were identified.

On the two questions, of the abolition of slavery and the predominance of federal over state rights, the war was fought. Ultimately the North, by force of greater numbers, prevailed, and the principle of federation was established. At the same time the negro population of the States became free.

The Growth of Constitutionalism.—It is, however, in the political upheavals of the century that the fullest results of the "Romantic Revival" and the Revolution which begot it may be seen. At first the restored monarchs attempted to ignore completely the popular demand for freedom. In Spain Ferdinand VII had made generous promises to the people, but immediately on his restoration he ignored these and ruled like a despot. But in 1820 a widespread revolt won a "constitution" for Spain, the same which had been drawn up in 1812 during the Peninsular War. It came to be known as the "Constitution of 1812," and furnished a standard to which other struggling nations aspired.

In France the restored Louis XVIII maintained a constitutional policy, but under Louis' brother and successor, Charles X, an attempt at a royalist reaction led to the Revolution of July 1830, which deposed Charles and appointed Louis Philippe Duke of Orleans as a constitutional king.

Even in England, in the first few years after the end of the Napoleonic wars, the Tories, who were in power, governed in a completely conservative manner, dealing severely with the popular agitations which marked the period, and which were in great part due to the dislocation of social and economic forces consequent on the Industrial Revolution. But in England too the panic reaction could not last, and a period of reform ensued.

The movement towards constitutionalism and towards nationalism may both be seen in the Emancipation of Greece from Turkish rule, and its establishment as a constitutional kingdom in 1829 under the rule of Prince Otho of Bavaria.

In 1831 Belgium freed itself from Holland and became a separate kingdom under Prince Leopold of Saxe-Coburg. Poland made a bid for freedom too but failed, and became more closely incorporated with Russia.

The movement towards constitutional government was felt so far afield as South America, where the possessions of Spain and Portugal (itself now a constitutional kingdom) broke away from the mother country and made themselves immediately or ultimately into republics.

Just as the revolution of 1830 in France had given a great impulse to the constitutional movement, so it was with a new revolution in February 1848, which overthrew the feeble Orleanist monarchy and made France a republic a second time. The year 1848 is sometimes called the "Year of Revolutions."

Especially was the impulse felt in many German states, where there was a conscious desire for national unity. This for the moment came to nothing, for there was no agreement as to the details of such a union. Many wished to exclude Austria from the union and accept Prussia as the leading state, while others would have assigned the presidency to Austria.

In Austria, Prussia, Hanover (now no longer joined to the English Crown since that had been worn by a woman), Saxony, and Bavaria the popular demands were granted only to be revoked in the two great states within a year.

In Italy there was a general cry for liberty and a rising in those parts still under Austrian domination, but for the moment the movement was stamped out. Austria looms large in this period as the arch-enemy of nationalism. Not only did she coerce the Italians, but she crushed resistance in Hungary and Bohemia, taking from the former the degree of self-government which she had already won.

The second French republic did not last long. The middle classes were republican, but the peasantry and working people had to be reckoned with, and Louis Napoleon, a nephew of the great Napoleon, was able by a *coup d'état* to have himself proclaimed Emperor with the title of Napoleon III.

As always, such a ruler found his best justification in military glory, and in 1854 France joined England in declaring war against Russia, whose aggression towards Turkey was alarming. The Crimean War ended in 1856 by the Peace of Paris, arranged at a conference of the European Powers, a method now becoming established in the settlement of terms of peace.

Young Italy.—Napoleon III found a new field for his activities in giving help to the "Young Italy" movement in which all the more ardent spirits in Italy were involved. It was felt, even by ardent republicans in Italy, that the only chance of national independence was to aim at a monarchy. The King of Sardinia was their obvious choice, and through the genius of his chief minister Cavour and the help of the French a new kingdom of Northern Italy was formed, from which Venetia alone in the North, the Papal States, and Naples stood out.

The genius of Garibaldi won Naples for Sardinia, and the Papal States with the exception of Rome, so that by 1861 only Rome and Venetia remained outside the new Italian kingdom. Both were soon included. Venetia was assured to Italy as a prize for her alliance in the "Seven Weeks' War" between Prussia and Austria in 1863. Rome was taken from the Pope in 1870, when the outbreak of the Franco-Prussian War made impossible the traditional French policy of supporting the papacy in a crisis.

An offer was made to the Pope to pay him yearly a large sum of money. He would hold a court, but would have no territory. The papacy rejected these terms, and the attitude of protest has never been abandoned. The Pope lives in the Vatican technically a prisoner on the defensive, and the problem of the Temporal Power is still a burning question among some Catholics. It was certainly a unique problem, but any other settlement than the one achieved would have prevented the realization of the great dream of Italian unity.

Prussia and Austria.—The Seven Weeks' War between Prussia and Austria was fought for the possession of the little states of Schleswig and Holstein, which the two had previously combined to wrest from Denmark. But the war had been consciously planned, by the great Prussian minister Bismarck, with the ulterior motive of achieving German unity under the presidency of Prussia. He knew that the depreciation in public opinion which Austria would suffer through defeat would make for this.

He had calculated rightly. Prussia won Schleswig and Holstein with immensely increased power on the Baltic Coast. Austria was henceforth cut off from all direct communication with the German states. A North German Federation was formed under the hereditary presidency of the kings of Prussia, and the Southern States were associated with it in military matters.

The Making of the German Empire.—One more great war was necessary to achieve the foundation of the German Empire. Bismarck had made up his mind that the German problem could only be solved "by blood and iron." He meant to fight with France, and in 1870, over a question of a disputed succession in Spain, the Franco-Prussian War broke out. The French under-estimated the strength of the enemy, and though they fought superbly they were continually out-matched in numbers. The armies sent by the lesser German states had been trained up to the standard of the splendid Prussian army. The Germans won in battle after battle. Napoleon III, brave but incompetent, at last yielded at Sedan. Paris held out for months, but had to yield at last. Alsace and Lorraine were lost to France.

In the full flush of enthusiasm the German states decided to unite as an Empire, with the King of Prussia as hereditary emperor. Each state remained self-governing in most local matters, but the Imperial Government is supreme in questions of war, foreign policy, and commerce, and there is more of the element of benevolent despotism left in the Government of the German Empire than in any country of Europe except Russia.

France became a republic for the third time, and has remained a republic ever since, while Austria, with her sphere circumscribed and defined, felt impelled to grant Hungary that system of self-government which has made it a constituent of her Empire. So recently as 1910 Portugal cast off the monarchy and declared itself a republic, though a royalist restoration is not improbable. In Spain there is always a strong republican party. Thus even in our own day the leaven of the French Revolution is at work, and as we shall see, not only

in Europe and lands won by Europeans; it is leavening Asia too. It is with justice that the French Revolution has been described as the greatest event in modern history.

THE GROWTH OF THE BRITISH EMPIRE

The great fact in British History since Waterloo is the growth of the Empire. Before that merely the foundations had been laid. The Empire looms so large in modern life that it requires an effort to realize this fact.

An immense impetus was given to the growth of the colonies by the extensive emigration which began soon after 1820, and which was the economic solution of the problems of dislocation and surplus population caused by the Industrial Revolution. Emigrants flocked to Canada, Australia, New Zealand, and South Africa.

In Canada the process of colonizing the lands westward of the earlier settlements went on apace.

Australia.—The great continent of Australia had been annexed by Great Britain in 1788, eighteen years after Captain Cook's famous voyage of exploration to its coasts. It is strange to reflect that the first settlers in Australia were convicts sent to work out their sentences under prison supervision and perform pioneer work in this great new colony. Hitherto English convicts had been sold into the plantations of the Southern States of America, but after the Declaration of Independence this was no longer possible. But there were other settlers too, and New South Wales became a regular colony. Between 1820 and 1830 settlements were made in Western Australia, and South Australia became a colony in 1836. Victoria, Queensland, and Tasmania were later offshoots of New South Wales.

The islands of New Zealand were also colonized. In Australia the natives made little or no resistance to the settlers. They were nomads of a low type. The Maoris of New Zealand were a better type, but have also practically died out before the advance of white men.

Africa.—In yet another continent, hardly known to Europe before the nineteenth century, the British race won a great heritage. The North of Africa had had their part in the successive Mediterranean civilizations since the days of Carthage, but the rest of the Continent was unexplored until the Portuguese in the fifteenth century skirted its coasts. They made trading settlements at various points, and other nations followed suit, but only in the South was a real colony founded—the Dutch colony of the Cape. This fell to Great Britain during the Napoleonic Wars, and possession was confirmed to her for a cash payment to the King of Holland at the post-Revolutionary settlement of Europe.

The large Dutch population became very discontented as the influx of Britishers increased. The abolition of slavery was their cardinal grievance, and they resented in general the English attitude of indulgence to the natives. The centre of Africa was filled with negro tribes, often extremely savage and nearly all of a low type though often surprisingly cunning and scientific in their methods of warfare.

The great mass of the "Dark Continent" was still vague and unexplored. But on the borders of Cape Colony there were endless opportunities for strife between natives and settlers, and the "Boers," as the Dutch colonists were called, resented bitterly the restraints which British rule imposed on their hostilities towards the natives.

Twenty years after the colony passed into the hands of Great Britain the majority of the Boers withdrew from the colony, "trekking" north, where ultimately they set up two independent republics across the Orange and Vaal rivers, republics which later became the Orange Free State and the Transvaal. Natal had been similarly occupied by Boers, who, however, evacuated it when it became a British colony in 1843.

With the growth of great colonies practically monopolized by a white population the problem of reconciling self-government with home influence came up. The problem has been solved in all the great British colonies of this type in the same way. They have passed through three stages to full self-government, and Canada has led the way in each.

In the first stage the colony has representative government, generally two Houses with a monopoly of legislation, but practically no control over the executive. In the second stage the colony acquires power over the executive, which becomes responsible to the legislative instead of to the home Colonial Office. In the third and last stage a complete federal government is set up.

Canada.—Canada has had its own legislature since 1791, but no further advance was made for nearly half a century. The French and British colonists quarrelled a good deal, and two separate revolts in 1837, Papineau's in Lower Canada and Mackenzie's in Upper Canada, brought about a complete reorganization. The two divisions of Canada were made into self-governing provinces of one state, and from this time dates Great Britain's definite policy of granting self-government to each colony as soon as it becomes sufficiently populated and educated to admit of such organization.

Nova Scotia and New Brunswick were made self-governing in 1848 and Newfoundland in 1858. On July 1, 1867, the organized states,

with the exception of Newfoundland, were federally united in the "Dominion of Canada," which the other settlements in this fast-developing land have since joined.

In Australia the growth of population received an immense impetus from the discovery of gold in 1851. By 1856 all the Australian states, except Western Australia, had their own legislature and executive. By this time the other states had successfully resisted the ingress of convicts. Western Australia, the least progressive of the states, continued to receive them for some time longer. It too received full self-government in 1890. The "Commonwealth" of Australia was established in 1900. It resembles more the federal government of the United States than that of Canada, which is more pervasive. In Canada it is understood that all such powers as are not expressly assigned by the "Dominion Act" to the provinces belong to the Dominion. In the United States and in Australia the Federal Government can exercise only such powers as are expressly delegated to it.

New Zealand has become a federation in which the provincial "parliaments" exercise strictly local powers.

South Africa has worked its way to a Federal Government through a much more chequered course than the other colonies.

Cape Colony received self-government in 1892 and Natal in 1893. But many problems had meanwhile arisen in connection with the Orange River Colony and the Transvaal. They were originally independent republics, but the manner of their organization and conduct affected British interests too closely to allow their status to go unquestioned. The Orange Free State was annexed by Britain in 1848, but restored to independence in 1854. The Transvaal was similarly annexed in 1877, but its rebellion was rewarded by almost complete independence in 1881, in spite of the practical defeat of British troops at Majuba.

This indulgence gave to the Boers a false impression of British weakness. The British population of South Africa were convinced that the Boers were aiming at supremacy. Feeling was aggravated by the treatment of British immigrants into the Transvaal, drawn by the discovery of gold mines there. The result was the outbreak of war in 1899.

The Boer War broke out as a result of the refusal of Kruger, President of the Transvaal, to listen to the representations of Cecil Rhodes, the Prime Minister of the Cape, on behalf of the "Uitlanders."

Each side under-estimated the courage and resources of the other. The war lasted two and a half years, with a terrible cost of men and money, but inevitably at last the republics were beaten and absorbed into the British Empire. They were at first crown colonies with a promise of self-government later, a promise speedily fulfilled by the Liberal Government, which granted them complete self-government in 1906.

Three years later the four South African colonies were federally united under the name of the Union of South Africa.

Meanwhile the "Dark Continent" had been rapidly opening up, and elsewhere than in the South British influence had spread.

The Scramble for Africa.—Almost as intimately involved in British interests as South Africa is Egypt in the north. From 1517 until Napoleon's famous expedition in 1798 Egypt had belonged to the Turks. Afterwards it fell into the hands of the Khedive Mehemet Ali, who held it as a sort of viceroy of the Sultan. Ismail, the grandson of Mehemet Ali, had fallen under the spell of the West, and he introduced Western education and Western science into Egypt. But his finances became hopelessly involved. He owed vast sums to France and England, and these Powers claimed to appoint representatives to supervise the collection of taxes and method of their expenditure.

Ismail secretly tried to stir up rebellions in Cairo, and the Sultan of Turkey, the nominal sovereign of the Khedive, was requested to appoint a new ruler.

This he did, but Arab rebellions followed, and the English sent soldiers to Egypt to subdue them. France and Italy refused to help, and therefore have never been able to object to the British occupation of Egypt. Egypt became a British Protectorate under a new Sultan when Turkey joined in the Great War of 1914.

Egypt has prospered marvellously under British rule, and has successfully withstood enemies from without.

To the south of Egypt proper lies the Egyptian Sudan. It is a desert region, with fierce and barbaric tribes dominating the more peaceful population. The great General Gordon worked wonders there from the time of his appointment to govern it in 1894, but his resignation ten years later was followed by a rising under an Egyptian pretender, who declared himself the successor of Mohammed and was called the "Mahdi." It was a dangerous movement.

The Sudan was but thinly garrisoned by Egyptian soldiers, and the British Government judged it best to withdraw from the region altogether.

General Gordon was sent to perform the dangerous and delicate task. He was shut up in Khartum, with only one white man and the natives to help him, when the Mahdi with a fierce horde surrounded the place. An army not far off at Suakin was inexcusably withdrawn, and Gordon was left for months without relief. The expedition which went at last arrived a day too late. Thirteen years later Sir Herbert Kitchener, with a completely reorganized

Egyptian army, reconquered the Sudan and destroyed the power of the Mahdi for ever.

The Explorers.—Meanwhile Europe had wakened up to the possibilities of Africa. Brave explorers, chiefly Britishers, had for a century been striving to make the mystery of the Continent less, when in 1880 the European Powers practically agreed to divide Africa between them.

The pioneer work of the Scotsman James Bruce, who in 1770 discovered the source of the Blue Nile, was followed up by Mungo Park's exploration of the Niger almost immediately afterwards.

In 1841 David Livingstone, the heroic missionary, began his life-work of exploration and evangelization. He traversed great tracts of the Continent for nearly thirty years, dying at last alone with the natives, who loved him and bore his body many miles to the coast to give it into the keeping of white men, until it was given burial at last in Westminster Abbey.

It was the work of men like these which fired the ambition of the European Powers to have their part in Africa. In the "spheres of influence" circumscribed in 1880 no outside power may interfere unless from such motives as shall have won the approval of the European Powers in general.

Only two native states stand without these spheres, the republic of Liberia and Abyssinia. Liberia was romantically founded by the reshipping of liberated American negroes to their ancestral shores, an enterprise begun in 1821. Abyssinia was an ancient native state which by its nature commanded respect for its independence.

In the rest of Africa, Germany and Portugal each have two tracts south of the Equator, one on the East and one on the West side. Between them cuts the British sphere from the South African Union up to the great lakes, including, besides the Union, the districts of Rhodesia and Bechuanaland, both under British protection. At this point German East Africa touches the Congo Free State, which belongs to Belgium and stretches to the West Coast.

North of the Equator Great Britain has British East Africa and Uganda, stretching up to Egypt. West of this stretches a vast desert territory allotted to France, to whom Morocco, Algeria, and Tunis also, either absolutely or practically, belong.

Tripoli has been won from the Turks by Italy, and on the west coast there are strips of territory accountable to France, Great Britain, and Germany. When the railway from Cairo meets that which is being constructed northwards from the Cape, great strides will have been made in the unveiling of the mystery of Africa.

The problem of political emancipation in Egypt, and more remotely in the other parts of Africa under British rule, will have to be faced in the future. It is essentially different from that in the colonies where the mass of the population is white. Already there is agitation in Egypt, yet thinking men can hardly approve the Egyptians as ready for self-government. The whole problem is involved in the larger question of the relation between the white and black races.

The Problem of India.—Somewhat similar, and even more pressing, is the problem which Great Britain has to face in its great dominion in India.

During the nineteenth century British power has advanced steadily in India. In Central India the destruction of the power of the Mahratta princes added largely to British territory. This was followed up by the annexation of the territory round the Lower Indus, the Punjab, and the larger part of Burmah.

The widespread mutiny of 1857, which spread through nearly all the native soldiers in Northern India, illustrates some of the difficulties of governing an alien people. It was completely suppressed within a year, but at the cost of much misery and many lives.

An immediate result was the dissolution of the East India Company and the taking over of the government of India by the Crown. No war has since taken place within India, though there has been much fighting on the borders. Two-thirds of India is now directly under British rule. One-third is still ruled by native princes, but owning British sovereignty.

India has prospered mightily under British rule. Railways and canals have connected up distant parts of the Continent. A system of irrigation has done much to prevent the terrible famines which were once the scourge of India. Manufactures have been introduced, and the cotton goods of Bombay threaten to oust those of Lancashire from the markets of the world.

It seems an anomaly that a small country like England should control the destinies of India and its teeming millions; for India with its tale of ancient civilizations is very different from Africa. But it must be remembered that England's rule and policy has alone made possible, even remotely, some sort of unity for India. The civilization which England has consistently tried to introduce is breaking down the divisions of race and caste and religion. But the movement is necessarily slow. Here, as in Egypt, there is a class of political agitators, chiefly students, but no one can justly claim that India is in any way ripe to rule itself.

So on all sides there is peace and prosperity within the Empire. But thinking men can hardly contemplate the situation altogether with complacency. There is danger in too much decentralization, and it is important that, with the loosening of the material bonds which formerly tied the colony to the mother country,

the ties of sentiment and sympathy should be emphasized. With the Eastern nations waking up to Western civilisation the "yellow peril" is no mere bogey, and can only be faced by solidarity between the different parts of the Empire.

PROGRESS IN EAST AND WEST

The great fact in the modern world is democracy. Everywhere the trend is towards popular government, and its almost inevitable accompaniment, a measure of economic socialism.

In England, for instance, the democratic government is theoretically complete, short of manhood suffrage. In practice the party system acts as a check on popular despotism, the House of Lords really representing the Conservative party, and acting as a check when the Liberals are in power.

Free education, free meals, and medical inspection of school children, the taxation of the higher classes to lessen the burdens of the poorer people are all aspects of State socialism which the most pronounced Conservative tends now to accept as part of the natural economy.

A marked feature of the modern state system is the minimization of Church influence. A natural result of that system of toleration, which was initiated by the repeal of the Test and Corporation Acts in 1828 and Catholic Emancipation in 1829, is the practical equality of the sects. The mediæval function of the Church as a keeper of the public conscience has disappeared, and the State performs the function itself.

Yet there are numerous signs of discontent with English democracy as it is worked. In the vital questions connected with the relations between capital and labour, there is an increasing impatience of political methods and a tendency to appeal to economic coercion by means of strikes.

There are many who favour the Referendum as a surer means of keeping legislation in touch with popular feeling.

Others still would dispense with Parliament, and establish more completely that system of bureaucracy which Parliament has in fact, through the increasing complexity of public business, found it convenient to employ.

Thus there are many problems still to be faced in the working out of democratic principles. But the importance of these principles, whatever be their form of working, is ingrained in the minds of modern men. Even the great yellow populations of the Far East are fast adopting them.

China and Japan.—Before the nineteenth century the two great nations, China and Japan, had hardly touched the destinies of Europe. To-day they are intimately connected, for good or evil, with the Western world.

The Chinese have a civilization older than any in Europe. They belong to the Mongolian race, taking that class in its larger acceptation. By the sixth century B.C. the Chinese knew how to write, and had established records which give a fairly authentic story accounting for the previous 2000 years. In the sixth century the philosophic but materialistic teaching of Confucius was established, and in the second century B.C. Buddhism was introduced from India. In the ninth century A.D. they had already invented printing.

In the thirteenth century the Mongols proper conquered China, and it is of the splendours of the Court of Kublai Khan, a ruler of a Mongol dynasty, that the famous mediæval traveller Marco Polo tells the tale. The Chinese reasserted their independence in the next century, but in the seventeenth century a barbarian branch, called the Manchus, seized power, and it was a Manchu dynasty which was ruling when the revolution of 1913 turned China into a republic.

Previous to this the name of China had become almost symbolical of the blindest conservatism. European traders brought tea from China in the seventeenth century, but all intercourse with the West was strenuously resisted. Attempts to exclude British trade led to the "Opium War" of 1840, after which Hong Kong was given up to Great Britain and certain other ports were opened to British trade. A few years later England and France joined in reprisals against China for the imprisonment of some Englishmen, and more ports were opened. Soon after the English helped the Chinese Government to put down a semi-religious revolt, led by a mad adventurer against the Government.

Meanwhile there was no progress in China. She had early developed an exquisite taste in silk and pottery, but the arts were stereotyped, as was the system of education, which consisted of a mass of traditional facts handed on from one generation to another.

Japan, too, when it first attracted the notice of Europe, was as anxious as China to escape it. Japanese history can only be traced back as far as the seventh century A.D. The Japanese had probably taken possession of their islands about six hundred years before. They are a people of mixed race, but probably have Chinese blood in their veins, and resemble Chinese somewhat in appearance, but ethnologists are inclined to insist on an Aryan element in the race.

Their history was not unlike that of the nations of Europe in the early Middle Ages. They were ruled by an Emperor called the "Mikado," but a kind of feudalism grew up and ultimately prevailed. Portuguese traders visited Japan in the sixteenth century and Jesuit missionaries followed in their steps, but not much progress was made. The Dutch made some settlements in the islands, but the

Japanese shut themselves up in an obstinate mediævalism.

The Awakening of Japan.—At last in 1854 Japan was reluctantly persuaded to open certain ports to the United States and Great Britain; Russia and Holland soon obtained similar privileges.

In 1862 a Japanese embassy was sent to travel through Europe and America to study Western ways. Everything was new to them. In the mid-nineteenth century Japan had no idea of modern inventions. With the reports of the embassy a vast enthusiasm for progress grew up, but the progressives had to fight a rabid obstructionism. In the process the traditional feudalism was broken down, and the Mikado became the progressive head of a progressive State.

The story of Japan in the last forty years reads like a fairy tale. The Japanese became greedy of progress. A fine navy and army were soon formed. Electric light, telegraphs, and telephones were introduced into the country. Universal education became the rule. In time the land won a parliament, though the Mikado is still more powerful than most constitutional kings.

Japan, a small nation, about as big as Great Britain, first proved her new-found strength in a struggle with China.

The Chino-Japanese War broke out in 1894. The cause was the alleged intention of China to invade Korea, the peninsula lying between the two countries. Contrary to expectation, Japan won easily on land and sea.

But the Japanese had never really feared China. She anticipated a Russian domination of China, and her anticipations were justified in so much as Russia stepped in to deprive Japan of the fruits of her victory. Japan bided her time, but in 1904 she went to war with Russia. The Russo-Japanese War is the most significant war of modern times.

There had grown up a Russian tradition by which that country was believed to have vast military resources and a perfect military organisation. Great Britain had been in constant fear of Russian aggression in India. It was this fear which caused the war between England and Afghanistan in 1879.

A guarantee of help from Great Britain, if any other Power should join Russia against her, encouraged Japan to declare war. She was consistently victorious on land and sea. The fiction of Russia's efficiency was shattered. In battle after battle Russia lost more men than fell altogether in the Boer War. The Japanese more than justified the reputation for courage and efficiency which they had won in their war with China.

She won Korea, and Russia gave up all claims on Manchuria, which was restored to China, but the important result of the war was the shifting of standards. Japan sprang into place as a first-class Power, and the Russian bogey no longer caused panic fear.

There are signs too that Chinese progress may receive speedy and incalculable increase. Many reforms have been recently carried out, and on February 12, 1912, China became a republic. For the last four centuries European peoples have been exploiting the lands and riches of the East. Already the tide has turned. The islands of the Pacific and Indian Oceans are being won back by Asiatics. There is a vast influx into South Africa, Australia, and Western America. It may yet be the fate of Europe to defend itself against the power of progressive Asia.

Meanwhile a recent conflict between Western ideas of freedom and the traditional despotism of the East has been watched with breathless interest by all the world.

The Turko-Balkan War.—It was not until 1898 that the winning of Greek independence of Turkey found a sequel in the struggle for freedom by the other Balkan and Danubian provinces still in the hands of the Turks. The rule of the Sultan over Christian populations has been ever oppressive, and any effort towards freedom has been met by brutal reprisals. In 1877 and 1878 Russia fought Turkey in support of a nationalist movement among those Slavonic peoples. It began in Bosnia and Herzegovina, and was joined by Servia, Bulgaria, and Montenegro. As a result of the war Roumania, Servia, and Montenegro won their independence; Bosnia and Herzegovina were placed under Austrian administration, and became part of her Empire in 1908. Bulgaria still paid tribute, but later won her independence.

Promises of reform within the territory remaining to Turkey were made but never carried out, in spite of the efforts of European diplomacy.

At last in 1912 the Balkan States took matters into their own hands, and went to war on behalf of their co-religionists in Albania and Macedonia. Naturally in case of victory territory won from the Turk was to be divided between the allies.

The Balkan States (Bulgaria, Servia, Greece, and Montenegro) in going to war with Turkey defied a declaration of the Great Powers that they would agree to no change in the *status quo* in South-East Europe.

They were splendidly victorious. Macedonia and the whole of Thrace were taken, and when Adrianople fell the Turks agreed to terms of peace.

Unfortunately the allies could not agree on the division of the spoil, and a new war between them broke out. Bulgaria, which had been the leading spirit in the resistance to the Turk, was badly beaten by Servia and Greece, and invaded by the Roumanians, who now interfered. What-

ever be the ultimate settlement with regard to the lands conquered from the Turks, they are at least freed from the Turkish domination. Slowly but surely the Turk is being pushed out of Europe. Yet even in Turkey there is question of reform, but so far the Young Turk party has achieved but little.

The Turkish population is brave and sober enough, but the despotism of the Sultan lies heavy upon them, and inveterate Mohammedanism opposes all progress.

Turkey, like Russia in a less degree, is an anomaly in a modern world of progress.

COURSE OF READING

In general it may be taken as a good arrangement of a course of reading on any period of history to begin with something in the shape of outlines (this is the function of the article to which this course of reading is appended) and then turn to bigger books. Standard histories of the period, which, though not always to be read steadily through, may be "dipped" into where they treat of specially interesting subjects. Sometimes the bigger histories are works of literary genius, and tempt the reader to continuous reading. When this is the case so much the better. The third stage in the study of a period is to read monographs on aspects of the time which make some special appeal to the student, or others, which, less interesting in subject, have some special charm of style. The cream of all historical reading is biography, and among good biographies the student will do well to range at large. It is always valuable and fascinating to read contemporary documents, and, indeed, such reading is indispensable to the real appreciation of a period. Such documents are being increasingly printed and reprinted in easily available forms.

Anthropology, the study of man's place in the animal kingdom, constitutes an important branch of science, and may or may not be studied by the historian. The best book to commence with is *Anthropology* by E. B. Tylor, an inspiring outline. This breaks up the ground generally. The anatomical aspect may well be followed up in T. H. Huxley's *Man's Place in Nature*, but the reader is advised not to base his views of evolution upon Huxley. *Natural History of Man* by J. C. Prichard has chapters on the same aspect. (See also Zoology for Evolution and Origin of Species). An excellent popular outline of the modern knowledge of the first men is given in chapters xli., xlii. and xliii. of *Science from an Easy Chair*, by Sir Ray Lankester; follow this by *Ancient Hunters and their Modern Representatives*, by W. J. Sollas. The problem of Animism may be followed up in Prichard, and more elaborately in Tylor's *Primitive Culture* (chaps. xl.–xli.); religion and mythology in this book too, and further in J. G. Frazer's *Golden Bough*, and Andrew Lang's *Myth, Ritual and Religion.*

Ethnology, the story of man as divided into races, may well be commenced by reading *Ancient Society*, by L. H. Morgan, which deals with the evolution of man from savagery. *Totemism and Exogamy*, by J. G. Frazer, is also concerned with primitive society, but may be taken as supplementary. For ethnology proper A. C. Haddon's *Races of Men* is a suitable outline; *The Wanderings of Peoples*, by the same author, may be taken as a sequel. The classical treatise of J. F. Blumenbach, *De Generis Humani Varietate Nativa*, is in Latin. *The Races of Man*, by J. Deniker, can be read after Haddon, and also A. H. Keane's *Ethnology* and *Past and Present.*

The beginnings of *Civilizations* are treated of in Morgan's *Ancient Society* (above); further information may be had in Tylor's *Early History of Mankind*, Lord Avebury's *Prehistoric Times* and *Origin of Civilisation.*

Egypt.—The study of the foregoing books should have given a sufficient general history of the beginnings of races and racial distribution, and have prepared the way for a special study of the different early races. For those who do not wish to study ethnology, except as an introduction to the study of the early races, Haddon's *Races of Men, Wanderings of People*, and Morgan's *Ancient Society* may be selected. Maspero's *Dawn of Civilisation* (vol. i. of *History of the Ancient Peoples of the Classic East*, edited by Sayce) may then be read, and the story may be followed out in *The Struggle of the Nations* and *The Passing of the Empires*, (vols. ii. and iii. of the same work). Egypt is treated here with the other early empires, and this is probably the best way to study its history. A useful supplement is *New Light on Ancient Egypt*, also by Maspero. A fuller and more specialized treatment of Egypt will be found in *A History of Egypt* by Flinders Petrie. Useful sidelights may be had from *Records of the Past*, first and new series, from *The Tell-el-Amarna Letters*, by H. Winckler, and also J. P. A. Erman's *Life in Ancient Egypt.* For the Ptolemaic period read *The Empire of the Ptolemies*, by J. P. Mahaffy; the Roman period, J. G. Milne's *A History of Egypt under Roman Rule* (see also Rome, below); *A History of Egypt in the Middle Ages*, by S. Lane-Poole; A. A. Paton's *History of the Egyptian Revolution*, and D. A. Cameron's *Egypt in the Nineteenth Century.*

Babylonia and Assyria.—Maspero's *Dawn of Civilisation* (dealing with Chaldæa as well as Egypt) is a suitable introduction. More specialized is *A History of Summer and Akkad*, by L. W. King, which should be read for the early races of Babylonia until the foundation of the

monarchy. Maspero's *Struggle of the Nations* introduces Assyria, and this may be followed by R. W. Rogers' *History of Babylonia and Assyria.* Read, further, *A History of Art in Chaldæa and Assyria* by Perrot and Chipiez; and *Records of the Past* first series edited by S. Birch (vols. i. and alternate vols.), and new series edited by Sayce (vols. i.–vi.) give translations of ancient monuments.

Israelites.—H. Ewald's *History of Israel* is the best book to use as a foundation for the study of the history of Israel. The bulk of the book is the history of the Israelites from the Exodus to Christ. Primitive history has an introductory chapter, and later events an appendix. Sayce's *Early Israel and the Surrounding Nations* is a good corrective and supplement. *Cuneiform Inscriptions and the Old Testament* by Schrader is good for its special purpose, and there are innumerable books on special aspects of the Israelites in the Biblical period.

Hittites and Phœnicians.—Maspero's *Struggle of the Nations* (see Egypt, above) gives a good introductory sketch and can be followed by *The Passing of Empires.* More specialized are Sayce's *The Hittites* and Messerschmidt's *The Hittites.* Read G. Rawlinson's *History of Phœnicia* for the Phœnicians, and J. Garstang's *Land of the Hittites* links up Hittites and Phœnicians. For those who can read French, the geography, art, and architecture of Phœnicia are dealt with in Renan's *Mission de Phenicie;* and R. M. Burrow's *Discoveries in Crete* gives the results of research on that Phœnician site.

Persians, Medes, and Parthians.—Read *The Five Great Monarchies, The Sixth Monarchy,* and *The Seventh Monarchy* by G. W. Rawlinson. *Media* by L. A. Ragozin, and *Parthia* by G. W. Rawlinson are useful so far as they go, and Sir H. C. Rawlinson's *Cuneiform Inscriptions of Western Asia* and Kersharp's *Studies in Ancient Persian History* supplement various aspects. S. Lane-Poole's *Mohammedan Dynasties,* Sir J. Malcolm's *History of Persia,* and Sir C. R. Markham's *A General Sketch of the History of Persia* (the last two modern), bring Persian history up to the present era.

Greece.—A scholarly and interesting outline of Greek history is supplied by Professor Bury's *History of Greece to the Death of Alexander the Great.* J. P. Mahaffy's *Greek Life and Thought from Alexander to the Roman Conquest* and *The Greek World under Roman Sway* take up the tale from the point at which Bury ends, but give, of course, fuller treatment. The reader who has mastered these is prepared for fuller and more specialized treatises. Professor Ridgeway in *The Early Age of Greece* discusses the problems connected with the relations between the civilization of Mycenæ and the civilization of Greece. *New Chapters in Greek History* by Percy Gardner may be read for a clear and scholarly account of the recent excavations in the region of Greece and the conclusions to which they lead. The greatest of the larger histories of Greece is that of George Grote. The first part dealing with "legendary" Greece is now of little value; but the second part, dealing with "historical" Greece, holds its place, although even some of this is now obsolete. But the serious student who would know his Greece thoroughly had better master Grote. Its chief value is the exposition of the nature and working of the Athenian democracy (read especially chap. xxxi. vol. iv.); and the chapters on Socrates (lxvii. and lxviii. vol. viii.) and the Athenian empire (xlv. vol. v.) should be read by every student. For military history Grote is not valuable, and a better account of some of the wars may be found in G. B. Grundy's *The Great Persian War and its Preliminaries.* The first great authority on the Persian War is the Asiatic Greek Herodotus, whose *History* may be read in an English translation by G. Rawlinson, or in two volumes by G. C. Macaulay. Herodotus devotes six books to the preliminary history of the combatants. An exhaustive study of the Peloponnesian War will be found in the article under that title in the new edition of the *Encyclopædia Britannica,* and a contemporary account is furnished in the *History* of Thucydides, whose treatment in its concern with the "science of government" is almost modern in tone. The speeches can hardly be authentic, but they are its most valuable part for the light they throw on contemporary feeling and thought. Jowett's translation is supplemented by a volume of notes. Xenophon's *Memoirs* should be read for a contemporary account of Greek history after the decline of Athens. *Alexander's Empire,* by J. P. Mahaffy, supplements the outlines for that period. *Some Aspects of Greek Genius,* by S. H. Butcher, focuses attention on the Greece that lives, and Warde Fowler's *City State of the Greeks and Romans* is an eminently readable summary of the constitutional history of Greece and Early Rome; read also A. H. Greenidge, *Handbook of Greek Constitutional History.* Mahaffy's *Social Life in Greece from Homer to Menander,* and Wincklemann's *History of Ancient Art.* E. Abbott's *Pericles and the Golden Age of Athens* is an especially valuable monograph on the most brilliant period of Athenian history (compare this with the masterly picture of Pericles by Thucydides), and B. Wheeler's *Alexander the Great* should be read, and the Greek Lives in Plutarch's *Parallel Lives.* (See also Greek Language for Literature.)

The Roman period of Greece already outlined by Mahaffy's *The Greek World under Roman Sway* is also dealt with in the *History of Greece* by G. Finlay (see also Rome, below), which covers the period from 146 B.C. to A.D. 1864 (Tozer's edition, Clarendon Press). Jebb's

Modern Greece and Sergeant's *Greece in the Nineteenth Century* may be read as supplements.

Rome.—An excellent little outline of Roman history, covering the period from the origins to the Fall of Rome, is furnished by a volume of the *People's Books, A History of Rome*, by A. F. Giles. The best outline on a larger scale is Pelham, *Outlines of Roman History*, a masterly treatise published as an article in the new edition of the *Encyclopædia Britannica*, and as a separate work. Two other complementary outlines which are less emphatically constitutional are How and Leigh's *A History of Rome to the Death of Cæsar*, and Bury's scholarly and interesting volume *The Students' Roman Empire*.

After reading these, Warde Fowler's *City State of the Greeks and Romans* will be found illuminating on early Roman constitutional history, and the same writer's suggestive essay *Rome* in the *Home University Library* may be read with advantage.

At this point turn to larger books. The standard work among these is the late Theodor Mommsen's *History of Rome to the Death of Cæsar*, to which is appended for completeness, though it is hardly on the same scale, a companion volume entitled *The Provinces of the Roman Empire*. All the volumes are published, in an English translation, by Messrs. Macmillan. The work without the supplementary volume is also to be had in Dent's *Everyman's Library* (4 vols.). Mommsen, like Grote, is especially valuable, because a point of view enthusiastically held inspired his work to the level of literature. He merely touches on the vexed question of the origins of the city, and passes on to his main theme, the fall of the Republic. He found a parallel between ancient and modern conditions, and treated his characters as vividly as though they were modern. No student of Roman History can dispense with this work.

A popularly written and profusely illustrated *History of the Romans*, by Victor Duruy (Eng. trans., 6 vols.), deals with the general history of Rome to the barbarian invasions, and is a very pleasant work.

The struggle between Rome and Carthage, forms the fourth and last part of *Carthage* in the Story of the Nations series, but the whole volume may be read with profit.

Further light on the republican period may be got from a recent book by W. E. Heitland, *A Short History of the Roman Republic*. The last century of the Republic has been a favourite theme for historians, and the student attracted by this period will find ample reading. The beginnings of the Revolutionary period are treated in A. H. J. Greenidge's *History of Rome from 133 B.C. to A.D. 70*, of which only one brilliant volume was completed owing to the author's early death in 1906. The same writer's *Roman Public Life* in *Macmillan's Handbooks of Art and Archæology* is also an attractive work dealing with Roman Institutions.

Warde Fowler's *Social Life in the Age of Cicero* gives the atmosphere and local colour valuable as a setting for the political story, and should certainly be read. The same writer's *Life of Cæsar*, and the *Life of Cicero* by Strachan-Davidson, both able biographies (Heroes of the Nations series), are valuable for this period.

The little volume *Julius Cæsar* in the *People's Books* is an admirably succinct, scholarly, and living study.

Cæsar's Conquest of Gaul, by T. Rice Holmes, should be read by all interested in the military side of Cæsar's activities, and all students should read at least part of Cæsar's *Gallic War* in the original or in one of the numerous translations.

Further contemporary atmosphere may be obtained in the translation of the whole *Correspondence of Cicero with his Friends*, by E. S. Shuckburgh. Some of the best of Plutarch's *Lives* are drawn from this period. The best are those of the two Gracchi, Marius, and Sulla, Pompeius and Cæsar, Brutus and Antony.

For the history of the empire, Bury's work may be followed by H Stuart Jones's *Story of the Roman Empire* and W. T. Arnold's *Roman Provincial Administration*, and by the portion of Mommsen's work dealing with this period. The *Life of Augustus* in the Heroes of the Nations series is an appropriate biography to read at this point.

J. S. Reid's *Municipalities of the Roman Empire* deals with an important phase of imperial history. Dill's *Roman Society from Nero to Marcus Aurelius* is also valuable as a picture of the life of the times.

At this point the student would do well to turn to Gibbon's great work, *The Decline and Fall of the Roman Empire*. Edward Gibbon lived from 1737–1794, but his work is still the standard treatment of the Empire in its decline, and J. B. Bury's elaborate edition with its generous footnotes brings the work abreast of modern research. The first larger and really valuable part of Gibbon's work deals with the period from 180 to 641 A.D. The most famous portion is the fifteenth and sixteenth chapters, giving the early history of Christianity and its relation to the Roman government. There is a certain amount of historical truth in the study, but facts and proportions are distorted by the ironical attitude of Gibbon towards Christianity. Even Gibbon's first part treats of a period which has already ceased to be Roman, and is labelled for convenience the "Middle Ages." For later history of Rome, see Middle Ages and Italy.

A valuable illustrative volume for the whole course of ancient Roman History is H. Stuart Jones' *Companion to Roman History*.

The Middle Ages

The period loosely called the "Middle Ages" from the break up of the Roman Empire to the period of the Renaissance and the Reformation is so enormous and complex that it does not readily lend itself to outline treatment, and the attempt at such treatment has seldom been made. The most satisfactory text-book dealing with the whole period and a sufficiently adequate introduction is *Europe in the Middle Age*, by Thatcher & Schwill. After reading this, the beginner would do well to turn to the first three volumes of Messrs. Rivington's *Periods of European History, The Dark Ages*, by C. Oman, *The Empire and the Papacy*, by F. F. Tout, and *The Close of the Middle Ages*, by R. Lodge. The brilliant and suggestive essay, *Mediæval Europe*, by H. W. C. Davis in the Home University Library, may then be read with appreciation and profit.

After this preliminary reading the period may best be studied in sections either chronological, or according to various aspects. It would be well to concentrate first on the period of the break up of the Roman Empire and the bararian invasions. For the former subjects chaps. xxix.–xxxvi. of Gibbon's *Decline and Fall* (ed. Bury) should be read, and for the latter chaps. xxvi., xxxviii., xlv, and lii. Chapters (besides the xvth, and xvith), dealing with Christianity are xx., xxi., xxviii., xxxvii., xlvii, and xlix.

L. Duchesne's *Early History of the Christian Church* may be read in an English translation, and is a scholarly yet popular account of the origin of the Roman Church, the first heresies, &c.

A further vivid study of those branches of the barbarian peoples who successively invaded Italy in the "Dark Ages" will be found in Hodgkin's *Italy and her Invaders*. Henry Bradley's study, *The Goths*, gives a rapid survey of the history of the Goths "from the earliest times to the end of the Gothic dominion in Spain." The early part of Milman's *History of Latin Christianity*, a work of considerable literary quality, covering the whole of the Middle Ages, may be appropriately read at this point. The *Life of Constantine* in the Heroes of the Nations series gives a good picture of the beginning of the period, and of one of the characters who determined in part by his deliberate policy some main features of its history. The first two volumes of the *Cambridge Mediæval History* (a collaborative and elaborate work in course of publication) deal with the Empire after Constantine.

The early part of Lavisse and Rambaud's excellent and scholarly *Histoire Générale* is also interesting and valuable. Gregorovius' standard work, *The History of Rome in the Middle Ages* (tr. Hamilton), treats the history of the papacy from the year 400 in the form of biographies of the Popes. Bury's *Later Roman Empire* is invaluable for the story of the Eastern Empire from 395 to 800, to be read also in Finlay's *History of Greece*, and Oman's *Byzantine Empire*, a smaller book. The *Life of Theodoric the Goth* in the Heroes of the Nations series, should be read as a treatment of a character unique in its interest, and a career concentrating the main forces of the period.

J. R. Green's brilliant studies, *The Making of England* and *The Conquest of England*, should certainly be read by all interested in Early English history, though the author's conclusions are not now generally accepted. A more recent book, *England before the Norman Conquest*, by C. Oman, is admirably fresh and original, and embodies the results of much modern research. An alternative volume is *The History of England before the Norman Conquest*, by Thomas Hodgkin (the first volume of the *Political History of England* (12 vols. Longmans).

The Full Middle Ages

The irruption of the Northmen, the foundation of the Holy Roman Empire, and the development of feudalism seem to mark the beginning of a second stage in mediæval history, and the student might well end this stage with the end of the thirteenth century. The reader will naturally turn to the volumes of the *Cambridge Mediæval History* dealing with the period, when these shall have appeared. Gibbon is still valuable on this period, and his chapter on Charles the Great (chap. xlix.) and those on Mohammed (chaps. l. and li.) should be read. The *Life of Charles the Great*, by Einhard, a friend and contemporary of the Emperor, should certainly be read. Written, of course, originally in Latin it may be had in an English translation. This may be followed up by Asser's *Life of Alfred*, for though a century divides them there are many parallels between these two great sovereigns. Students especially attracted by these subjects should read also the volume on *Charlemagne* in the Heroes of the Nations series, and *Alfred the Great*, chapters by Frederic Harrison, Sir F. Pollock, and others (ed. by A. Bowker). These may be followed up by James Bryce's brilliant monograph *The Holy Roman Empire*.

Milman's *Latin Christianity* is valuable still for this period, and an excellent corrective to Gibbon. Especially good is the *General Survey*, the fourteenth book at the end of the work, which might be read with advantage at this stage. Then turn to the chapters on Charlemagne, the Ottos, St. Bernard, St. Louis, the Crusades, Hildebrand, Innocent III, and Boniface VIII. The chapter on the monastic order of St. Benedict is good, and might be read previously to the much fuller treatment in

Montalembert's *Monks of the West*, the classic work on Western monasticism previous to the eleventh century. The author's great object of enthusiasm was St. Bernard, but he died before his work reached the eleventh century. Three of his five original volumes deal with the development of monasticism in England. A sixth and seventh volume, published after his death from fragments of his writing, deal respectively with the influence of monasticism on the feudal nobility and lay society up to the eleventh century, and Gregory VII and the Investiture Contest. After reading all or parts of this work every reader should read from cover to cover J. C. Morison's perfect little study, *St. Bernard's Life and Sermons*. For the later developments of monastic life it will be well to turn again to Milman's chapters on St. Dominic and St. Francis. Two rather old-fashioned but certainly not negligible books which deal with the general aspects of the Middle Ages are Hallam's *Middle Ages* and Guizot's *Lectures on Civilisation in Europe*. In spite of the immense impetus to the study of mediæval things in recent years there has as yet been no book treating philosophically of the Middle Ages as a whole in the light of recent research. Until such a book arrives Guizot's treatment must remain the most valuable short book on the subject. Guizot is especially important to read, because he brings the insight of a practical statesman to the treatment of old problems. His book, with that of Hallam, created a revolution in historical study. Every student should read at least the last chapter in Hallam's *Middle Ages* treating of the state of society. Of the others the first four chapters on France, Italy, and Spain are the best.

Those who wish to study the history of any special country in detail will generally have to turn to works written in the language of that country, but one advantage of the study of mediæval history is that the civilization of the period is so cosmopolitan that more than at any other period the history of one European nation illustrates that of the rest.

This is illustrated by the brilliant *History of France* down to Francis I, by Jules Michelet (translated by W. Hazlitt). It is a series of brilliant studies and reflections on mediæval movements and typical mediæval characters. Every student should read the splendid chapters on the eleventh, twelfth, thirteenth, and fourteenth centuries, the studies of Charles the Great, Louis the Fat, Philip Augustus, St. Louis, Philip the Fair, the Crusades, the Albigenses, the Communes, and Gothic architecture.

After reading Michelet on these subjects it would be well to turn for contemporary reading to Suger's *Life of Louis the Fat* and Joinville's *Life of St. Louis*. Students anxious to master particularly the constitutional and political details of the history of Mediæval France should supplement the more general reading by a study of the *Histoire de l'Europe et particulièrement de la France*, by Jallifier and Vast. This has the advantage of being admirably illustrated. Special points should be further studied in the *Histoire de la France*, written on the co-operative system and edited by Lavisse. Four large volumes are devoted to mediæval history.

Those who wish to specialize on the history of Germany may read in English E. F. Henderson's *History of Germany in the Middle Ages*. Bryce's *Holy Roman Empire* is concerned largely with Germany, and should be supplemented by Fisher's *Mediæval Empire*.

For the mediæval history of Italy the student will find the following interesting and useful, Butler's *Lombard Communes*, W. C. Hazlitt's *History of Venice*, and *The Two First Centuries of Florentine History*, by Villari (translated into English).

Most readers will naturally wish to concentrate on English history. E. A. Freeman's *Norman Conquest* tells in minutest detail the story of the events leading up to the conquest of 1066, but it is exceedingly elaborate. The chief modern treatment of the political history of England in the Middle Ages is to be found in vols. ii. and iii. of *The Political History of England*, vol. ii., 1066 to 1216, by George Burton Adams, M.A., and vol. iii., 1216 to 1377, by T. F. Tont, M.A. A less severely political treatment and on a slightly smaller scale will be found in H. W. C. Davis' eminently readable volume, *England under the Normans and Angevins* (1066–1272) (vol. ii. of *A History of England* in 6 vols., edited by C. W. C. Oman). These might be followed up by Mary Bateson's *Mediæval England* in the Story of the Nations series. It is a gem in its remarkable generalization and wealth of illustration on the social life of England in the Middle Ages. *Social England*, edited by H. D. Traill (vol. i. to accession of Edward I) will also be found useful and interesting. Stubbs' *Constitutional History of England to* 1485 is indispensable for every student of English institutions in the Middle Ages. Recent research has shown some of Stubbs' conclusions on the Norman period to have been erroneous, and *Supplementary Studies*, by Petit-Dutaillis, should be read alongside to furnish the necessary modifications.

After mastering Stubbs the student should be ripe for the brilliant monographs of the late F. W. Maitland, none of whose works may be neglected by a student of mediæval history. We may mention *Domesday Book and Beyond*, *Roman Canon Law in the Church of England*, and Pollock and Maitland's *History of English Law before the time of Edward I*, which might be read successively at this point. They are all three of a specialist nature, but the distinction of style and essential lucidity of treatment make them fascinating reading. *Feudal England*, by J. H. Round, might appropriately follow, but it

is essentially stiff reading. All who wish to appreciate the exact nature of the Great Charter should read *Magna Charta* by W. S. M'Kechnie—"A Commentary on the Great Charter of King John, with an historical introduction." This too is close reading. The student who has pursued any line of reading in mediæval history, as far as the thirteenth century, when so many mediæval institutions reached their zenith, will do well to turn to various monographs tracing the history of some of these institutions through the period. Rashdall's *Universities of Europe in the Middle Ages* should be read by all. H. C. Lea's *History of the Inquisition in the Middle Ages* is a standard work on an important subject, and should also be read, but the student cannot accept all the conclusions, and should bear in mind that Lea wrote with an unconscious but real anti-Roman bias. *Roman Law in Mediæval Europe*, by Paul Vinogradoff, treats an important theme in a lucid manner. Gierke's *Political Theories of the Middle Ages* (tr. Maitland) gives an insight into one side of mediæval speculation. R. L. Poole's *Illustrations of Mediæval Thought* is a slighter but very readable work. H. O. Taylor's *The Mediæval Mind: A History of the Development of Thought and Emotion in the Middle Ages* is an admirable conspectus and very readable.

The chief thinkers of the Middle Ages belonged to one or other of the two great orders of friars. The Franciscan movement, and in a lesser degree the Dominican, has been the subject of keen interest and minute study. Everyone should read the *Life of St. Francis* by Paul Sabatier (English translation) and *The Little Flowers of St. Francis* (tr. T. W. Arnold), which work of the Saint gives the most intimate insight into his mind and character.

This should be followed up by Eccleston's charming chronicle of *The Coming of the Friars Minor into England* (translated by Father Cuthbert, O.S.F.C., and furnished with an admirable introductory essay, which is the best account in English of the early Franciscan movement). A. G. Little's *Grey Friars in Oxford* is a scholarly study of an important side of Franciscan activity in England. Eccleston's chronicle in the original Latin, with other interesting records of the English Franciscans, may be read in *Monumenta Franciscana*, edited by J. S. Brewer and R. Howlett in the *Rolls Series*. Brewer's preface to the first volume is especially interesting and valuable.

The chronicles and other documents printed in the famous *Rolls Series*, available in every public library, are of course for the most part in Latin, but for those who do not read Latin the prefaces are often suggestive and helpful.

It will be interesting, after making some study of Franciscan history, to turn to that of the Dominicans. The best early life of St. Dominic is that by the thirteenth-century Dominican Jordan of Saxony. It must be read in the original Latin, and is to be found in the Bollandist *Acta Sanctorum* (Aug. 4).

The best modern *Life* of St. Dominic is that of J. Guiraud in the series called *Les Saints* (Eng. translation, 1901). The best short account of the history of the Dominicans in England will be found prefaced to the *Life of Cardinal Howard* by C. F. Palmer.

Every student of the thirteenth century will find himself attracted by the ideal of English kingship, Edward I, and everyone should read the masterly little study *Edward I* by T. F. Tout in the Twelve English Statesmen series. Another fascinating biography, and appropriately to be read in connection with the Dominican and Franciscan movements, is that of Innocent III. Those who read French will find Luchaire's book *Innocent III* the best on the subject. For the Crusades there is an excellent article by E. J. Barker in the *Encyclopædia Britannica*, which may be followed up by H. Von Sybel's *History and Literature of the Crusades* (Eng. tr.).

Later Middle Ages

With the end of the thirteenth century a new period with a touch of modernity seems to open, and further reading on the Middle Ages may be grouped round the fourteenth and fifteenth centuries. The central fact of English and French history is the Hundred Years' War, and English and French history loom largest in this period. Vols. iii. and iv. of the *Political History of England* are valuable, and Stubbs is still the first authority on the period. The later part of his work requires less correction from modern research than the earlier. For a clear understanding of the military history of the period Oman's *History of the Art of War in the Middle Ages* must be read. A good narrative of the first part of the Hundred Years' War will be found in *The History of Edward III* by James Mackinnon. For contemporary colour every student should sample Froissart's *Chronicles*.

In the fourteenth century economic discontent becomes a marked feature of the times, and it is important to master the nature of mediæval economy. The parts dealing with the Middle Ages in *Pitman's Economic History of England* by H. O. Meredith (an excellent handbook) will make an appropriate introduction to the subject, which may be followed up in Cunningham's *Growth of English Industry and Commerce* (Early and Middle Ages). A literary treatment of the most picturesque aspect of the century's history is given in G. M. Trevelyan's *England in the Age of Wycliffe*. *The Great Revolt of* 1381, by C. W. C. Oman, is a valuable study of the Peasants' Revolt. *Social England* (vol. ii. to death of Henry VII) should be read also. Both Chaucer and *The Vision of Piers Plowman* should be read for the sake of contemporary colour.

The economic history of the time is intimately connected with the ferment in religion of which Wycliff is the fountain head. Milman's *Latin Christianity* is still excellent on this period, and may be followed up by the first volume of Creighton's *History of the Papacy*. The fascinating study of the teaching and personality of Wycliff himself may be well followed up in the introduction to the *Fasciculi Zizaniorum Magistri J. Wyclif*, ed. Shirley (*Rolls Series*) and in *Huss and Wiclif* by J. Loserth (Eng. tr.). Complementary accounts of the "Babylonian Captivity" of the Papacy, so important a feature of the period, will be found in Creighton and in Pastor's *History of the Papacy* (Eng. tr.). The history of the Hussite movement and the conciliar movement of the fifteenth century follow naturally on the fourteenth-century upheaval, and should be followed up at this point in Creighton, Milman, and Pastor.

For the progress of the second part of the Hundred Years' War, J. Gairdner's small book, *The Houses of Lancaster and York, with the Conquest and Loss of France*, should be read. Sir J. H. Ramsay's *Lancaster and York: A Century of English History*, a work of immense learning, may be consulted on points which the student may wish to have elaborated.

The most attractive figure in fifteenth-century history is Joan of Arc, and every student of the period will wish to know all that can be known about her. Michelet's vivid sketch is one of the most brilliant parts of his *History*. Her character and career have provoked much controversy, and there are many points of view. An enthusiastic modern treatment is furnished by Andrew Lang's *The Maid of France*.

The effect of the French wars in disorganizing English administration is illustrated in *The Paston Letters*, which are invaluable as contemporary documents, giving the very atmosphere of the fifteenth century. They have been edited with the closest care and scholarship by Gairdner. From their quaintness and sobriety the student will turn with a keener appreciation to the study of the Renaissance spirit.

The Renaissance and the Reformation

With the beginnings of modern times history becomes altogether more complex, and, as a natural consequence, there are fewer great books attempting to deal philosophically with great tracts of the period. But there is an increasing number of specialized standard works dealing minutely with various periods.

As a general introduction to the study of modern history nothing could be better for its clearness and general arrangement than the *Outline of Modern History* by Jules Michelet. Beginning with the fall of Constantinople in 1453, it has been translated and brought up to date by Mrs. W. Simpson. The best available summary of modern political history to the early nineteenth century is the *Manual of History of the Political System of Europe and its Colonies*. These might be followed up by Robertson's *Survey of Europe* in the *Introduction* to his *Charles V*. The formation of the European monarchies, which is partly prelude to and partly an aspect of the Renaissance, may be followed up with profit for individual countries. For England the early part of Hallam's *Constitutional History of England* should be read. For Italy there is a short English summary of Sismondi's *Italian Republics*. For Spain Prescott's *Ferdinand and Isabella* is the standard work. But Robertson's work gives better than any other a general view of forces and events at work in the Europe of the sixteenth century. *The Renaissance*, the first volume of *The Cambridge Modern History*, a work of immense specialization and research, is admirably divided up and may be read through or consulted on special points. It is almost purely political in its method and selection.

A vivid account of the geographical discoveries of the period will be found in *A Book of Discovery* by M. B. Synge.

For the Renaissance in its narrower literary and artistic aspects every student should read J. Burckhardt's *The Civilisation of the Renaissance in Italy*, and Michelet is again inspiring and illuminating. Various lectures on *The Renaissance* by J. A. Symonds should be read, and his elaborate work, *The Renaissance in Italy*, may be sampled.

Here with the vast development of personality, which is a note of the period, biography is all important. W. Roscoe's *Life of Lorenzo de Medici* is an appropriate biography to read at this point. There are numerous lives of Michael Angelo, and one of these should be read. Seebohm's charming work *The Oxford Reformers* should certainly be read. It gives an insight into English and European life as affected by the "New Learning." The *Life of More* by his son-in-law, W. Roper, should be read, and for a typical Renaissance *jeu d'esprit* More's *Utopia* (Eng. tr.) should be studied, as also should Erasmus' *Praise of Folly* (Eng. tr.).

The general history of the Reformation in Europe will be best read in Ranke's *History of the Popes*, and a further treatment of its progress in individual countries will be found in *The Reformation*, vol. ii. of the *Cambridge Modern History*, and in vol. iii., *The Wars of Religion*. The story of Holland's struggle for its liberty and religion may be read in Motley's *Rise of the Dutch Republic*. Most readers will naturally wish to read a good biography of Martin Luther. Unfortunately the subject has hardly ever been treated in an impartial spirit. Perhaps the best account is in Janssen's *History of the German People* (Eng. tr.).

The Reformation period in England may be read in vols. v. and vi. of *The Political History of England*, 1485–1547 by H. A. L. Fisher, and 1547–1603 by A. F. Pollard or alternatively in *England under the Tudors* by A. D. Innes, and *England under the Stuarts* by G. M. Trevelyan. A brilliant study on a large scale of the Reformation in England is J. A. Froude's *History of England*, 1529–1603. It is very partial and inaccurate, but the student should read it while discounting its tone and bias. Brewer's 2 vols., *The Reign of Henry VIII* (to 1530 only) give a vivid impression of their subject.

F. A. Gasquet's *Henry VIII and the English Monasteries* is a readable and scholarly account of a movement which amounted to a social revolution. The part of Cunningham's *Growth of English Industry and Commerce*, which deals with the period, should be read for an appreciation of the great economic changes passing over England at this time, and also Traill's *Social England*, vol. iii.

For a continuous history of the English Church during this period of reorganization, vol. iv. of *A History of the English Church* (ed. Stephens and Hunt) by James Gairdner is valuable and scholarly. It deals with the period from the accession of Henry VIII to the death of Mary. The tale is taken up in vol. v. *During Reigns of Elizabeth and James I*, by W. H. Frere.

Gairdner's monograph, *Lollardy and the Reformation in England*, should also be read. An elaborate study is furnished in R. W. Dixon's *History of the Church of England from the Abolition of the Roman Jurisdiction* (6 vols., 1529–1570). *Edward VI and the Book of Common Prayer*, by F. A. Gasquet and E. Bishop, is an important and illuminating study.

After the Scottish Reformation Scotland became more intimately connected with England, and it might be well to review at this point the relations between the two countries during previous periods. R. S. Rait's *Outline of the Relations between England and Scotland* (500–1709) forms an excellent popular outline, and might be followed up by P. Hume Brown's *Scotland in the Time of Queen Mary*.

The study of this period in English and Scottish history should be rounded off by a few important biographies. Gairdner's *Henry VII*, Creighton's *Wolsey* (*Twelve English Statesmen* series), *Queen Elizabeth* by the same author, A. F. Pollard's *Henry VIII* and *Cranmer*, and Julian Corbett's *Drake* may be recommended. For contemporary atmosphere Cavendish's *Life and Death of Thomas Wolsey* should be read.

Round Mary Queen of Scots a whole literature has grown, but the charming biography by Florence MacCunn may be specially recommended, and there is a study too in the *People's Books*. The study of *John Knox* by Mrs. MacCunn might be read or his *Life* by M'Crie, Knox's own *History of the Reformation in Scotland* should be sampled.

The Seventeenth Century

Two volumes of the *Cambridge Modern History* deal with the seventeenth century, vol. iv. *The Thirty Years' War*, and vol. v. *The Age of Louis XIV*. Michelet and Heeren on this period should be studied before reading up special points in these two large volumes. This would be an appropriate point to read Stubbs' *Lectures on European History*. They "form one historical drama, in which the reign of Charles V is the first, the period from his death to the beginning of the seventeenth century the second, and the Thirty Years' War is the third act." They are very illuminating in their masterly generalization. H. O. Wakeman's volume on the period from 1598–1715 in *Periods of European History* is eminently readable. Its method is selective. The development and influence of France is emphasized as of the first importance in the history of the period.

S. R. Gardiner's little volume, *The Thirty Years' War* in *Epochs of Modern History* is a fine study of the subject.

Gustavus Adolphus by C. R. L. Fletcher is a readable biography of the Protestant hero of the Thirty Years' War.

For the constitutional struggle in seventeenth-century England material abounds. The last word in research is to be found in the great works of S. R. Gardiner, *The History of England from* 1603 *to* 1642, *The History of the Great Civil War*, and *The History of the Commonwealth and Protectorate*, but to most students they will only appeal as books of reference. J. R. Green's narrative of the struggle in his *Short History of the English People* is especially vivid, and vols. vii. and viii. of the *Political History of England*, 1603–1660 by F. C. Montague, and 1660–1702 by R. Lodge give adequate narratives.

Gardiner's little volume in *Epochs of Modern History*, *The First Two Stuarts and the Puritan Revolution* (1603 to 1660) should be read by all, and no one should neglect his *Constitutional Documents of the Puritan Revolution*. The volume on *Oliver Cromwell* by H. C. Firth in the Heroes of the Nations series is especially fine both in matter and style, and should be read by all, as well as his *Cromwell's Army*. Lord Morley's biography of Cromwell is also valuable and suggestive, and there is a very complete and judicious study in the *People's Books*. Carlyle's *Letters and Speeches of Cromwell* gives contemporary colour, but has little value as history. The *Memoirs of Colonel Hutchison* and the *Diaries* of John Evelyn and Samuel Pepys should also be read, at least in part.

Pollard's *Factors in Modern History* deals suggestively with some of the constitutional problems of the period.

The real essence of the age of Louis XIV may best be found in Voltaire's *Age of Louis XIV and Louis XV*. For the history of the Revolution Macaulay's *History of England* is indispensable.

Seeley's *Growth of British Policy*, while perhaps rather over-emphasizing the part played by dynastic considerations in the relations between European states, is extremely suggestive and interesting.

The Eighteenth Century

For the general history of Europe in the eighteenth century Arthur Hassall's *The Balance of Power* (1715–1789) in *Periods of European History* is a good conspectus, and vol. vi. of the *Cambridge Modern History* also deals with the eighteenth century.

Of English history in the eighteenth century the monumental work of Lecky, *History of England in the Eighteenth Century*, gives an exhaustive analysis. Its seven volumes are made up of a series of essays rather than a continuous narrative. His treatment of the American War of Independence and of Irish history are especially good. Lecky is essentially readable, but for those who require shorter works C. Grant Robertson's excellent volume, *England under the Hanoverians*, may be recommended for its clear arrangement and grouping and its emphasis of outstanding features of the times. Vols. ix. and x. of *The Political History of England*, by J. S. Leadam and W. Hant, cover the political history of the period.

Lecky's treatment of the American War of Independence may be followed up in G. O. Trevelyan's *The American Revolution* (in progress). *The Early History of Charles James Fox* by the same writer is a gem of biography and should be read by every student of the period. Lord Rosebery's study of the younger *Pitt* should also be read. Leslie Stephen's *History of English Thought in the Eighteenth Century* gives an admirable impression of the intellectual atmosphere of the century.

The Expansion of England by Seeley treats in a clear and emphatic way of an important side of British development. Macaulay's essays on *Clive* and *Warren Hastings* should be read in connection with the history of India. Sir Alfred Lyall's *Rise and Expansion of the British Dominion in India* is a good short treatment of the subject and thoroughly up to date. For those who wish to turn back to the early history of India Elphinstone's *History of India in the Hindu and Mahometan Periods* is the best popular account. J. W. McCrindle's *Ancient India*, T. W. Rhys David's *Buddhist India*, and Stanley Lane-Poole's *Mediæval India* (Story of the Nations series) are all scholarly and readable monographs.

For the story of Canada Sir J. G. Bourinot's *Canada under British Rule*, 1760–1900, which reviews in its first chapter the colonization of the valley of the St. Lawrence by the French, may be recommended. A. G. Bradley's *The Making of Canada* is also good. It deals with the history of Canada from 1766 to 1814.

The French Revolution and the Romantic Revival

A vast literature has grown up round the various aspects of the French Revolution. The best short book to read as an introduction is Mignet's *History of the French Revolution* (1789–1814) (Eng. tr.), but Michelet's fuller treatment in the nine volumes of his *History of the French Revolution* has far greater literary charm.

Lord Acton's *Lectures on the French Revolution* are scholarly, illuminating, and original, like all he wrote. For those who care for the poetic method of history Carlyle's *French Revolution* may be recommended at this point. For the history of the Revolutionary and Napoleonic Wars the first 2 vols. of C. A. Fyffe's *History of Modern Europe* (1792–1848) is the best general account, as it is of the general history of the period. Hilaire Belloc's little volume on *The French Revolution* (Home Univ. Lib.) is useful as an analysis of character and motives, refreshing in its criticism of traditional views, and illuminating in its treatment of the military aspect of the Revolution. Vol. viii. of the *Cambridge Modern History* deals with the *French Revolution* and vol. ix. with *Napoleon*. A concise exposition of the influence of the French Revolutionary ideas on Europe is furnished by J. Holland Rose's *The Revolutionary and Napoleonic Era* (1789–1815). It should be read and followed up by the *Life of Napoleon* by the same writer, and by Lord Rosebery's *Napoleon, The Last Phase*. *Revolutionary Europe*, by H. Morse Stephens, in *Periods of European History* is a somewhat fuller treatment than that of J. H. Rose, on the same lines, emphasizing Napoleon's reforms rather than his conquests. Two out of the proposed three volumes of *A History of the French Revolution* by the same author have so far appeared. It is a detailed history (the second volume ends with the year 1793) and thoroughly scientific, correcting misstatement, and filling in gaps in the narrative of Mignet, &c. It was severely criticized by Lord Acton.

Seeley's *Life and Times of Stein* is illuminating as a study of the changes which took place in Germany in the Napoleonic era.

There is an excellent article on the Waterloo campaign in the *Encyclopædia Britannica*, and a recent small but vivid volume on the Battle of Waterloo by H. Belloc. The same writer's lives of *Danton*, *Robespierre*, and *Marie Antoinette* are all well worth reading. Mahan's *Influence of Sea Power on the French Revolution and Empire* deals with an important aspect of the period.

Oman's *History of the Peninsular War* is a masterly study.

The Romantic Revival.—For the general history of Europe in the nineteenth century, Fyffe's *History of Modern Europe* (1792 to 1878) is valuable. *Modern Europe*, by W. Alison Phillips, in *Periods of European History*, deals with the period from 1815 to 1899. *The War of Greek Independence* (1821–1833) by the same author deals with the political first fruits of the French Revolutionary movement. Vols. x., xi., and xii. of the *Cambridge Modern History* deal respectively with *The Restoration*, *Growth of Nationalities*, and *The Latest Age*.

The story of the making of Italy may be read more fully in *Modern Italy* (1748–1898) by Pietro Orsi. J. A. R. Marriott's *The Makers of Modern Italy, Mazzini, Cavour, Garibaldi*, might also be read, and Lord Acton's article of "Cavour" in *Historical Essays and Studies*.

Bismarck, A Political Biography, by Charles Lowe, should be read, both for its insight into the character of a great statesman and the history which he made. A smaller but excellent study of Bismarck by F. M. Powicke is published in the *People's Books*.

For English history in the nineteenth century there are vols. xi. and xii. of *The Political History of England*, 1801–1837 by G. C. Brodrick and J. K. Fotheringham, and 1837–1901 by Sidney Low and C. L. Sanders. Traill's *Social England*, vol. vi. (1815–1885) deals with aspects of English life of special importance in this period. Justin M'Carthy's *A History of Our Own Times* (5 vols.) but also condensed into 1 volume) is a popular and very readable account of the reign of Queen Victoria up to 1897.

Spencer Walpole's *History of England* (5 vols. deals with the period from 1815 to 1880, and *A History of Modern England*, by H. Paul (5 vols.) is a brilliant survey of the period from 1846 to the retirement of Gladstone in 1895.

The Development of Parliament during the Nineteenth Century by G. Lowes Dickinson gives in a short manner the steps by which the "democratization" of Parliament has been achieved.

Kinglake's *Invasion of the Crimea* is a standard work, and can be had in an abridged edition.

F. R. Cana's *South Africa from the Great Trek to the Union* should be read by all who wish to appreciate the problems of South African history and the events circling round the Boer War. The study of *Cecil Rhodes* in the *People's Books* may well be read in this connection.

For the general history of Africa the works of Sir H. H. Johnston are standard authorities, *A History of the Colonisation of Africa by Alien Races* and *The Opening-up of Africa*. J. S. Keltie's *Partition of Africa* may also be read, and is liberally furnished with maps.

A very readable book on a subject of compelling interest is *Great Britain in Modern Africa*, by Edgar Sanderson.

For Australia a good short and first-hand account of its development is furnished by Edward Jenks's *History of the Australasian Colonies from their Foundation to the Year* 1911.

A good manual sketching the history of China from the earliest times to the present day is that of E. H. Parker, *China: Her History, Diplomacy, and Commerce*.

The Civilisation of China, by H. A. Giles, and his *Chinese Biographical Dictionary*, contain a wealth of information on social life in China.

For Japan the best account of its modern progress is *Fifty Years of New Japan* by Count Okuma. Lafcadio Hearne's *Japan: An Interpretation* is interesting, as is also B. H. Chamberlain's *Things Japanese*.

E. O'Neill, M.A.

II. SOCIAL PHILOSOPHY

SOCIOLOGY

An outstanding characteristic of the present age is the attention given by various classes of men to social inquiries. The "social problem" every year becomes more urgent in its demands for a solution. A growing party in politics aims at the redress of social wrongs and at a higher standard of life for the workers of the nation. Social reformers and philanthropists, no longer acting on the impulse to relieve particular cases of obvious want, seek to discover the causes of distress and so attack the problem at its very foundations. Ministers of religion exhibit a growing tendency to preach Christianity not merely as a preparation for a future life, but in its relation to the difficulties by which individuals and communities are here and now beset. All classes of educated and cultured men are betraying the same increasing interest in the life and work of their fellow men.

It is from these circumstances that the study of sociology derives its interest and importance. The term is very often used in a more or less vague sense, referring to observations of particular aspects of the life of the whole nation or of parts of it. In the following article, however, we shall employ it in a narrower sense, meaning by it a scientific investigation into the origin and development of human society, ideas, and institutions. Even from this point of view there is, as we shall see, some uncertainty as to its precise meaning. Yet we shall be able to make sufficiently clear the general scope and methods of the social science. We shall first trace the historical development of the study, then give a short outline of its methods and the objects investigated by it, and conclude by indicating by what course of reading the subject may be studied in greater detail.

History of the Science.—Sociology, in the present-day acceptation of the term, is a science of quite modern creation. In Greece, it approximated to political science, which discussed the best method of securing to the citizen the greatest degree of good character; a character possible through the laws and institutions of an all-embracing State. The Roman ideas were not essentially different. The Greek influence is seen in the modern writers following the Renaissance. The doctrines of Machiavelli, Bodin, Grotius, Hobbes, and Locke, all tended to become theories of society regarded as a medium for the conscious realisation of human desires along the line of least effort. Even in so recent a thinker as Spencer a trace remains, in his view of man's submission to political subordination as due to experience of increased satisfactions through its means.

The founder of modern sociology, and the coiner of the term, was *Auguste Comte* (1798–1857). In the *Positive Philosophy* (1839), sociology is placed at the head of the sciences, as the most complex of them, dealing with the whole nature of the most fully organised being, and with the mutual relations of the social body. Human phenomena are as reducible to law as any others. The laws concerned are of two kinds—statical, the conditions of permanent existence, and dynamical, the laws of change; and, as an object must exist before it can move, the statical element in all cases takes precedence. The evolution of society depends on the development of knowledge, and this is controlled by the "Law of the Three Stages." Every society in its evolution passes through the *Theological*, *Metaphysical*, and *Positive* stages, though the evidence for this law is admittedly incomplete in any one society. The first is long and protracted. All things that affect the mind are conceived to be inhabited by spirits (*Fetichism*); a gradual reduction in the number of gods produces *Polytheism* and finally *Monotheism*. The second stage, where causes of phenomena are sought in abstract entities instead of supernatural volitions, is transitory, and passes into the final and permanent third stage, where it is seen that only phenomena and their laws can be known.

The æsthetic, moral, and religious sides of human nature are reducible to a similar order of development. In fetichism, priesthoods and

temples are absent, but arise with poetry, music, and the dance, in polytheism, where the concrete object is regarded only as the abode of the divinity. With the idea of the divinity as protector come patriotism and the military spirit, slavery, and caste. Monotheism brings a separation of spiritual and temporal power, and the surrendering of all coercion to the State; science advances and overshadows the æsthetic faculties, though these find compensation in pathetic portions of the Evangelist's narratives, traditions of saints and martyrs, erection of cathedrals, and choral music; the feudal system arises, and slavery becomes serfdom. The disappearance of the theological belief brings the decay of faith, and a free play for the spontaneous impulses of human nature. Universal selfishness is transformed into universal love, and the intellect is allied as a regulating influence with the affective functions; an aspiration after ideals taken from saintly and heroic examples leads to the religion of Positivism, the worship of Humanity.

Natural Selection.—The development of the study was after Comte profoundly influenced by the theory of natural selection. There had been long before Darwin tentative speculations on the evolutionary principle in nature. It was the *Essay on the Principles of Population* of Malthus (1798) which suggested the theory of natural selection to Darwin. The researches of Murchison, Buckland, and Lyell, among others, had familiarised the world with the idea of development in the physical and biological spheres. Buffon and Lamarck had already propounded their theories of evolution. Yet a strong opposition was offered to all attempts to apply these theories to man himself; the Old Testament teachings were influential, and the theory of evolution offered no hint of a means whereby the transmutation of species was brought about. This essential mechanism was supplied by Darwin's theory of natural selection (*Origin of Species*, 1860), that individuals perpetuated those variations which best fitted them to survive in the struggle for existence. This new theory enabled the study of man to be made a department of a higher biology, and brought all the phenomena of human development within the application of general causes, which have controlled the evolution of human life from its very beginning.

Herbert Spencer.—Darwin's theory was adopted by Herbert Spencer, who found an analogy between the social organism, *i.e.* the State, and a living body. Both increase insensibly from small aggregations, assuming a greater complexity of structure and an increasing interdependence of parts, of which the life of each is possible only through that of the rest; also, the life of a society is independent of and more prolonged than that of its individual parts, which die away while the whole body politic survives. An important difference, however, is that all members of society are endowed with feeling, and not merely a special tissue. Hence the welfare of individuals is not to be sacrificed to the supposed interests of the State, but on the contrary, the latter only exists to serve the citizens. This, however, leads to a difficulty, for, since the efficiency of a society is always greater than the sum of that of the separate parts, natural selection must act on the individual through society, *i.e.* the interests of the citizen are subordinate to those of the State. Hence it must either be the case that the individual has arrested the normal effect of natural selection—which is inconceivable—or Society must be organic in a different and wider sense than Spencer imagined, and subject to further-reaching principles than he conceived.

Spencer has thus made no advance on the English Utilitarians, Bentham and Mill, who regarded the science of society as the study of the paramount interests of the individuals within the consciousness of the political State. Accordingly, there has been a growing conviction of the impossibility of formulating the principles of human development if the "social organism" is identified with the political state. Society must be conceived as something more than political, and, in fact, social progress is shown in history to be associated with prominent types of social order organically connected with certain conceptions which have subordinated individual conception through extended periods of time. At every stage is found some dominant principle determining which among contemporary social systems will survive against the others.

Thus, in western civilisation we find, first, the principle of the greater efficiency of co-operation than of individual effort leading towards social organisation; second, the propelling force centred in the personality of some military chief; next, the subordination of the individual to military efficiency, the greatest advantage being the conception of exclusive citizenship derived from blood-relationship to a common deified ancestor. A later stage shows a sense of human responsibility outside the limits of subordination to the State. The State has still to maintain its military power against co-existing lower forms of society, yet social institutions are transformed by new ideas of freedom and tolerance. Slavery and the absolute power of the ruling classes decay, and give place to the conception of the native equality of man, to political enfranchisement, to the unlimited freedom of thought in every department of inquiry.

To sum up, while previous empirical systems have tended to construct theories of human society from introspective examinations of individual emotions, future theories must reverse this order, must regard as the controlling factor

in the evolutionary process, society considered in its more organic aspects, and must study the individual mind from this standpoint.

OUTLINE OF GENERAL THEORY

We may define modern Sociology as an interpretation of human society in terms of natural causation; as an explanation of the growth of human institutions by the operations of physical and psychical forces, working together in a process of evolution.

Nature and Scope of Sociology.—As to its exact nature and scope, varying views have been taken. Thus Comte considered that the life of society was one and indivisible, whence sociology must study it as a whole; others have relegated particular classes of social phenomena to special "social sciences," *e.g.* political economy, politics, reserving for sociology proper the study of general principles underlying the sub-sciences. Other views regard it as merely the sum of moral and political sciences, or identify it with one of the older special sciences. But since a science of sociology can be distinguished from the special social sciences, and be allotted the study of attributes common to all of these, it seems proper, as well as convenient, to regard it as the science of social elements; the common basis of the more particular subsciences, and furnishing its principles as their postulates.

Method.—Sociology is a concrete science, descriptive, historical, and explanatory. This implies that the field of observation is the whole history of mankind, that certain signs are found associated with certain phenomena, that a similar association is inferred to have existed in times past. Thus, as in all concrete sciences, the method is generalisation, verified by deduction; just as in the abstract sciences, the legitimate order is deduction, confirmed by observation. It is not meant, however, to confine these two methods, induction and deduction, to concrete and abstract sciences respectively, but just to keep description in advance of history, history in advance of explanation.

The traditional distinction (mentioned above) between social "statics" and "dynamics," and the greater importance attached by Comte to the former, seem to require that coexistences must be explained before sequences. Giddings, however, points out (*Principles of Sociology*) that these terms involve a misconception. All human phenomena are questions of dynamics, for all, coexistences and sequences, are products of social forces. Social structure results from forces in equilibrium, development and change from varying forces. The whole science is then a study of motion; the real division is of dynamics into statics and kinetics. Living organisms form a "moving equilibrium," in which an approximate equilibrium of internal forces is prevented from perfect equilibrium by external forces. It is therefore wrong to attempt sharply to divide the statical investigation of the internal equilibrium from the kinetic examination of the change.

The Fundamental Sociological Fact.—In recent years, varying theories of the characteristic marks of society have been advanced; —*Gumplowicz*, that primitive conflicts lead to amalgamations and assimilations of heterogeneous elements to form ethnical groups; *Novicow*, that conflict is progressively modified by alliance, and the physical struggle becomes an intellectual one; *De Greef*, that society progresses so far as conscious agreement displaces coercive authority; *Tarde*, that imitation is the primitive phenomenon, leading to mutual aid, division of labour, contract; *Durkheim*, that individual minds are increasingly coerced by external modes of thought and action; *Giddings*, that "consciousness of kind," which may be produced with other effects, by impression and imitation, causes alliances and contracts, and is thus the true principle to which all human development is to be referred.

Historical Evolution of Society.—We shall have to go right back to the earliest dawn of human history, when man is just emerging from the animal state. This took place, according to Darwin, in Africa, where those species of the monkey most related to man (gorilla and chimpanzee) are to-day found, and which gave the hot climate necessary when man lost his hairy covering, and adopted a frugivorous diet. An opposing doctrine places man's origin in a region extending along the north of Africa and south of Europe, as far as India; a doctrine based on such discoveries as those of the remains of anthropoid apes in France, Italy, Gibraltar, and of paleolithic implements in the valleys of the Ouse, Thames, Somme, Garonne, and Tagus. It is such discoveries as these which determine the social characteristics of the first men of whom we have any knowledge; together with the study of geological and biological facts, of a general parallel between some features of primitive society and of the lowest existing societies.

The first men lived in hordes, scattered over wide areas. Their numbers were very small, and increased from within by births and from without by the capture of women and children. The nature of the family at this stage has been the subject of much discussion and investigation. The older theory regarded the father as the head of a family of one or perhaps more wives and children; from this beginning arose, in time, a number of families all subject to the patriarch, and splitting up into separate tribes as their numbers increased. A typical example

was the case of the children of Israel. Maine, the chief exponent of this *Patriarchal Theory* in the nineteenth century, regarded the ancient Roman family as showing the true character of the primitive family—the paterfamilias possessed in the "patria potestas" unlimited power over wife, children, and slaves; women on marriage became subject to a new paterfamilias, all relationship was through males (*i.e.* was agnatic), and all clans and tribes were agnatic. But such a type was too complex to be primitive, and seems not to have occurred save with the Romans.

The patriarchal theory is not in accordance with the traditions or present institutions of civilised nations; many tribes appear to be tending towards it as a later development. Accordingly, through the researches of McLennan and others, belief in a maternal relationship has gained ground. The commonest marriage is temporary monogamy. In cases of desertion, the children remain with the mother and take her name. As the hordes become consolidated into clans, all members of the clan regard themselves as descendants of one ancestor, such as a deer, turtle, or elk. This is Totemism. Marriage is exogamous, *i.e.* between members of different totems, and descent is usually reckoned through mothers. The clan enforces rights and duties, marriage regulations, laws of property. Later arises the phratry, a brotherhood of subclans, formed from a larger clan. It develops the social and religious life of the community. The tribe is a military organisation, and develops in its council a military tradition.

At any of these stages—clan, phratry, tribe, the change from metronymic to patronymic relationship may occur. The chief factors are, marriage by capture, where the neighbouring tribes are hostile, the separation of women from their kindred by accompanying their husbands in hunting parties, the increasing value of the labour of women and children in the fields, leading to the desire for their retention, and finally, the adoption of the wife into the clan and totem of the husband. With these changes, the belief in the descent from totemic gods disappears, and is replaced by *Ancestor-Worship.* The head of the family is priest and proprietor; marriage is arranged with a view to the transmission of the priestly office; adultery is not merely an offence against the husband, but a sin; barrenness is a terrible crime; failing the birth of a son, the parental authority is transmitted to the son of a daughter "appointed" for the purpose. If a man dies childless, his widow is given in marriage to his brother, and their children regarded as his (Matt. xxii. 24). Further, clan headships tend to become hereditary, and the chief's personal possessions increase through inheritance, confiscation, conquest, and presents from the tribesmen. The Feudal System is the direct outcome of this type of society.

Hobhouse (*Morals in Evolution*) distinguishes "mother-right" from matriarchy, and with it connects his views on the position of women in early society. Under "mother-right," family relationships depend on the wife, who remains a member of her own family; the children take the mother's name and belong to her kindred, returning to them in case of desertion or divorce; the woman's brothers are her natural guardians and exercise all the rights and privileges of the position; property passes *through* the woman, if not *to* her. Yet the mother-right is compatible with the complete subjugation of women (Caribbeans, North American Indians). Woman's inferior right to protection of life and limb, her drudgery while the men fight, the prevalence of polygamy and the capture and exchange of wives all point to the inferiority of women.

This is not to say that the lower races hold their women in complete subjection. Westermarck (*Origin and Development of Moral Ideas*) rejects this as a general state of affairs. In several cases she is superior to the man. Thus, among Columbian Indians, women interfere and prevent bloodshed in drunken brawls; they are often admitted to and speak at the councils of the Navahos, and in other tribes women are always consulted before a bargain is closed in trading.

The position of women depends on their economic value, which raises their status among agricultural tribes, where the cultivation of the land is regarded as women's work; on the magical ideas connected with women, *e.g.* their uncleanness, which gives them a certain power over men; on the number of girls born, and on the prevalence of infanticide.

Consolidation into Nations.—Returning from this digression to our sketch of the historical evolution of society, we may refer briefly to the increasing consolidation of clans into tribes, and tribes into nations, and the growth of the complex civilisation of to-day. The key to this development is found by Hegel in a process of self-realisation; of intellectual progress and widening freedom. Freedom is at first considered abstract and existing only in one person, God or the king. In Greece, many could be free. Rome incorporated the substance of freedom in the formal law of personal rights. In Christianity the idea is fully matured, and all men may be free. A second doctrine is that of Comte, who, as we have seen, found the law in a merely intellectual development.

According to Spencer, who based his assertions on observation and induction, it is the military power which shapes the whole political organisation. At first, it integrates the society, but, if continued afterwards, leads to a "segmentation," a sharp division of society into castes, with a minute supervision of every department of human affairs. Industrialism is subordinate, and personal freedom disappears. If the

military power, however, becomes no longer predominant, an age of industrialism follows, which is only possible through the previous military constitution of society, and causes in its turn, freedom. Giddings, criticising Spencer, agrees that in the age of integration a society must be military. Afterwards, however, a free type is created by the energies liberated on the decline of militarism, and the next stage of progress is the organisation of free forms of society under the protection of law, which alone make industrialism possible.

A complete account of the development of human society will also trace the growth of ideas and institutions for which we have only space here for the briefest mention.

Growth of Institutions.—Thus we are led into the highly debatable question of the nature and origin of moral emotions, the notions of "ought," "good," "virtue," "merit," the altruistic sentiment. We follow the growth of modern institutions for maintaining law and order, in their various stages from direct retaliation, the blood feud, compensation for injuries, to collective responsibility, with a central authority employing the judicial duel, the oath, outlawry, the ordeal in its redress of wrongs, to the later stage of extreme rigour of the punishment of crime, which is a revolt against authority, and lastly, to the reformatory treatment of crime, which is regarded as an outcome of definite psychological or physical conditions.

Slavery is traced from its origin through economic reasons and capture in war, as an advance on slaying of captives, in its different aspects in Greece, Rome, and America, to its gradual transformation in Europe into serfdom, and its final disappearance as the greater efficiency of free labour was realised.

In the regard for human life, investigation shows how this is held cheap in various primitive societies, especially the lives of strangers; and the part played in increasing its value by religion (*e.g.* Laws of Manu, Roman Catholicism), the crusades, chivalry, and the increasing authority of rulers.

We may trace also the changes in the attitude of man towards supernatural beings; the different degrees of immortality attributed to gods, their human needs and sensitiveness to insult and worship, the practice of sacrifice, the right of sanctuary, their moral growth, and the comparative characteristics of the religions of Peru, Chaldea, Persia, India, and Europe.

The study will also find a place for such topics as hospitality, treatment of children and old persons, property, truthfulness and honour, suicide, celibacy, cannibalism.

COURSE OF READING

The study of sociology may be conveniently entered upon with *Elements of Sociology* by Giddings. Herbert Spencer's volume on *The Study of Sociology* may also be perused, as explaining the difficulties, both in the student and in the phenomena to be investigated, that must be overcome in order to make progress in the science. The relations of Sociology to the other branches of philosophy are discussed in Sidgwick's *Philosophy, its Scope and Relations.*

Larger treatises may now be attempted. These should include Kidd's *Social Evolution*, Giddings's *Principles of Sociology*, and Mackenzie's *Introduction to Social Philosophy.* Only when the student has thoroughly grasped in broad outline the nature and scope of the science should he proceed to such compendious and difficult works as Spencer's *Principles of Sociology*, and *Principles of Ethics*, Westermarck's *Origin and Development of Moral Ideas*, Frazer's *Golden Bough*, and Hobhouse's *Morals in Evolution.*

Notable books that have contributed to the historical development of the science should be studied, and some may be procured in cheap editions. Comte's *Positive Philosophy* is best read in Harriet Martineau's translation in two volumes. Mill's *Logic* discusses (Book VI) the methods appropriate to the science. Darwin's *Origin of Species* is in Cassell's "People's Library."

Primitive society may be studied in Marett's *Anthropology* (Home Univ. Library), Tylor's *Anthropology* and *Primitive Culture*, Lubbock's *Origin of Civilisation*, and Maine's works, including *Early Law and Custom*, and *Early History of Institutions.* Modern forms of civilisation are discussed in Kidd's *Principles of Western Civilisation*, and in various *Encyclopædia Britannica* articles, as well as in Sidgwick's *Development of European Polity.*

Many of the principal contributions to the science of society are not to be found in lists of sociological references, but must be sought in the periodicals in which they were first published.

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POLITICAL ECONOMY

Political Economy, or Economics, is the study of man in relation to the ordinary business of life. On the one hand, it is a study of wealth, as it deals with the objects which men and nations pursue as constituting their material well-being; on the other, it is part of the study of man, for more than any other agency except his religious ideals, man's everyday work and the material resources he thereby acquires have moulded his character.

But though economics deals with questions so vital to the well-being of man, it is yet, as we shall see, a modern science, and is almost entirely the development of the last three centuries. It is still, indeed, in a transitional state, and we shall be able to trace two tendencies in it, one the more abstract and mathematical, and the other more concrete, occupied with the observation of countless phenomena, past and present.

We shall be able, however, to present certain fundamental ideas of the science, which are by no means difficult to understand, though, rejecting confused conceptions and inexact reasoning, they require a certain degree of concentration of mind.

We shall, therefore, give in brief an outline of the historical development of economic theory, and follow this with a general account of the principal topics discussed by economists. We shall conclude with a course of reading in which the study may be further pursued.

History of the Science.—Ancient and modern theories of economics owe their essential difference to the varying constitution of the State. In the ancient State, in which slavery was a permanent and integral feature, industry is held in contempt, as (with few exceptions) unworthy of the free man. The servile classes, the agents of production, are debarred from civil interests, and unfitted for combination and personal initiation. Moreover, the military habits of the nation, with their consequent insecurity of life and property, make impossible the accumulations of capital and the systems of credit of modern times. Hence, even in Greece, we find no systematic economical discussions, but only isolated, though brilliant ideas. The Greek philosophers regard the individual as entirely subordinate to the State, which controls his every activity. The citizen is regarded as the possessor, not as producer of wealth; and wealth is considered, not for itself, but as subservient to higher ends. The chief theories are those of Plato, Xenophon, and Aristotle.

Plato (*Republic*) finds in community of wives and property the most perfect means of subordinating individual interests to those of the State; the foundation of the social organisation is traced chiefly to economic causes. A self-contained State is desired, whence foreign trade is discouraged. The industrial classes are despised, and all economic dealings are subject to active State control. *Xenophon*, though preferring agriculture as a fitter preparation for military life, and as leaving leisure for political duties, lays greater stress than other writers on trade and manufactures. To promote these, he emphasizes the need of peace between the nations, and the equitable treatment of foreigners.

Aristotle does not clearly mark off economics from politics. The individual, with him, is not so subordinate to the State as with Plato, for human society is due not to economic necessity but to certain natural social impulses. Hence he allows a certain degree of personal freedom, and rejects the communityof wives and property. Slavery is approved, and cultivators of the soil, mechanics, and artificers, are debarred from all share in the government. He distinguishes between the acquisition of natural products, as in hunting, cattle-rearing, &c., and the active exchange of products, with money as its medium. The expression of his views on Capital is metaphorical rather than scientific; thus, no loans should bear interest, since money is barren, and cannot produce money.

The Romans also regarded industrial arts as contemptible. Though, in early times, paying great attention to the land, large numbers of slaves were soon introduced, the prisoners taken in the wars. Roman economic ideas are mostly copied from Greek writers. Cicero, Seneca, and Pliny urge a return to the land, as a refuge from the evils of the times, but show no clear appreciation of economic evils and their remedies. Plinyresembles the modern mercantilists in advocating the necessity of keeping money inside the country; Varro and Columella, like the eighteenth-century physiocrats, see in agriculture a cure for the social degeneracy of their age.

Nearly all the Roman jurists disapprove of loans on interest. Thus, the rate of interest was fixed by the laws of the Twelve Tables, and interest on loans was in 341 B.C. entirely prohibited by the Genucian Law.

Middle Ages (A.D. 400–1300).—The first part of this period, consisting of a long and painful

struggle towards the establishment and consolidation of ecclesiastical and civil systems, was unfavourable to any varied economical activity. Under feudalism, the wealth of the lord consisted of agricultural produce and dues paid in kind; his retainers were paid by their maintenance. Manufactures and commerce were impossible. Yet, towards the thirteenth century, factors appear making for the development of industry and trade—the Crusades, bringing different nations into contact; the rise of the burgher class, and the independence of towns; the formation of guilds, and the demand of cities for the produce of the country.

The Catholic Church was a powerful influence, in preaching industry, thrift, sanctity of promises, the dignity of labour, the claims of the poor, and fair dealing between man and man. Slavery passed into serfdom, permitting some domestic relations and religious life. Later, as the landlord recognised the superior efficiency of free labour, serfdom passed away altogether; a process hastened by the moral influence of the Church, and by the sovereign's jealousy of the great lords. Workers and contractors now became clearly separated. A capitalist class arose and developed commerce and manufactures. Trade corporations (thirteenth century) were legally regulated and recognised; these served as rallying points for the industrial workers, whose technical skill and moral habits they greatly improved.

The Modern Period.—The Middle Ages may be said to end with the thirteenth century. From this time the mediæval system rapidly and spontaneously collapsed, and a wonderful development is seen in economic activity. With the rise of paid armies, peaceful activities, to provide the necessary cost, became prominent. Manufactures and commerce were stimulated by the discoveries of the art of printing, of the mariner's compass, of America and a new route to the East, and by the establishment of public credit in the Italian cities of Genoa, Venice, and Florence. At first, there was no corresponding theoretical development. By the seventeenth century, however, as industry became an increasing concern of the Governments, as the only means, through taxation, towards military and political ends, a school of writers arose whose doctrines became known as the *Mercantile System*. The chief of these thinkers were Scaruffi, Bodin, Stafford, Copernicus, Watteville, and Child. As they observed the increasing importance of money, as a peculiar form of wealth, in a class by itself, to produce which Governments paid ever greater attention to industry, they developed a tendency to value too much the precious metals, to put too great a stress on foreign trade as against internal, on dense populations as an element of national strength, and to overestimate the capability of Governments to secure by legislation the ends they considered desirable.

In its extreme form, the Mercantile System regarded money and wealth as identical, whence it is the aim of a country to retain as much as possible of the precious metals. To this end, export of its own manufactures is to be encouraged, imports discouraged, and the difference is to be received in gold or silver. The most favourable "balance of trade" is to be secured by prohibition of, or high taxes on imported goods, by bounties on exports, and by restrictions on the export of gold and silver.

Yet in England there was at the same time growing up a body of opinion in direct opposition to the Mercantile System—that natural wealth consisted not of gold, but of the gifts of nature and the products of labour; that the true aim of national effort was the accumulation of the necessities and luxuries of life; that freedom of trade should be substituted for the system of prohibitions, duties, and bounties. Traces of such views are found in *Hobbes* (*Leviathan*) and *Sir William Petty*. *Sir Dudley North*, a convinced free-trader, held views approximating to those of Adam Smith. *Locke* strenuously opposed the debasement of the currency, but still retained some ideas derived from the mercantilists.

Physiocratic School.—These English ideas, popularised and developed in France, where Diderot was striving after a complete social reorganisation through freedom, led to the rise of the *Physiocratic School*. Originated in 1755 by Cantillon, the teachings of the school were given systematic form by *François Quesnay* (1694–1774) and *Vincent de Gournay* (1712–1759), who called themselves and their adherents the "physiocrates," or "économistes." Society, they affirmed, consists of individuals having the same natural rights; each individual best understands his own interests, and naturally pursues it. No interference by Government is just save in so far as the natural freedom of one is incompatible with the rights of others. Hence each has an absolute right to the fruits of his own labour, and property is sacred.

They insisted on freedom of exchange, unrestricted competition, and the abolition of privileges and monopoly. Further, only agricultural labour is "productive," for this alone adds to the quantity of raw material available for human needs, and to the wealth of the community. Manufactures merely give a new form to materials drawn from the earth; their increased value represents only the quantity of materials consumed in the process. Commerce only transfers wealth; the gains of the commercial classes are at the cost of the rest of the nation; they are drawn from the superfluous earnings of the agriculturists. Free-trade, and the policy of *laissez-faire*, or minimum of governmental in-

terference are advocated, and a single tax on land as the simplest means of raising the revenue. Minor writers were Mirabeau, Larivière, and Turgot. The Physiocratic system soon had its day, but lived again—as to certain of its elements—in the system of Adam Smith.

Adam Smith.—Returning to England, we find a stagnation of thought in the early eighteenth century. The first advances were made by *Berkeley* and by *Hume* (*Political Discourses*, 1752), who discussed physiocratic and mercantile views on commerce, money, and interest. Following these is *Adam Smith* (1723–1790), whose *Wealth of Nations*, in five books, was published in 1776. His general theory is explained in the first two books. Labour is emphasized as one of the sources of the necessities of life—whence his difference from mercantilists on the one hand, and physiocrats on the other. The productivity of labour increases with its division, which originates in man's propensity to exchange. Exchange implies a certain capital, and demands a market, and money, as the medium of exchange. From the exchange of goods arises the notion of value, and value in use is distinguished from value in exchange—purchasing power. The measure of value (*i.e.* in exchange) is the labour required to produce the commodity—"equal quantities of labour, at all times and places, are of equal value to the labourer."

Money is then not the real or natural price, but the nominal or market price. Price (natural) consists of three elements: Wages, the reward of labour; Profit, from the use of accumulated stock; and Rent, which arises when all the land of the country has become private. The market price fluctuates, but tends to approximate to the natural price. Wages, Profits, and Rent vary according to the circumstances of society. Wages vary with the demand for labour, but a minimum wage must suffice to maintain the labourer and his wife and family. Profits also vary with the demand for labour, but in the opposite direction. Rent is a monopoly price, the highest that a farmer can afford to give, and is thus an effect, not a cause of high prices. Capital, the accumulated material employed to produce a revenue to its owner, may be "fixed," or remaining in his own hands, or "circulating," when the goods are sold and replaced by others.

Smith distinguishes between "productive" labour, which is realised in a particular object, and the useless, "unproductive" labour of magistrates, lawyers, &c.; the first alone is employed by capital. Capital is increased through productive labour, whence the thrifty man is a friend to the State, the spendthrift a public enemy. The annual produce of the land is increased by augmenting either the number of labourers or their productive power. Either involves additional capital. As the capital of a State increases, the growing difficulty of finding new employment for it leads to competition between capitals and lowering of interest. Agriculture offers the greatest remuneration to capital, since "Nature labours along with man," and replaces both the capital and the rent of the landlord. Smith in the third book treats of the development of industries by modern European nations; in the fourth, he argues against the mercantile system, and the physiocratic doctrine of the sole productivity of agricultural labour; in the fifth he discusses methods of taxation.

Malthus.—Following Adam Smith are *Bentham* (*Political Economy*, 1843) and *Lauderdale*, in substantial agreement with him, and then *Malthus* (1766–1834), whose *Essay on the Principles of Population* appeared in 1798. The period was one of industrial unrest. The prolific inventions of the time, of cheap earthenware (Wedgwood), of the spinning-jenny (Hargreaves), the steam-engine (Watt), the looms (Cartwright and Crompton), enormously stimulated manufactures, but created hardships of their own; whence the beginnings of socialism and of the "social question." The *Essay* was a reply to William Godwin, who taught that the existing wealth was sufficient for everyone, if it were equally divided, and dreamed of an era of perfect happiness on earth when all men by moderate exertion earned a moderate sufficiency. Against this, Malthus contended that such a state of prosperity would imply an unchecked increase of population and a consequent scarcity of food, on which the former struggle would again take place. In the re-written treatise of 1803, Malthus lays down the proposition that while food can be made to increase in an arithmetical ratio, population increases in a geometrical, and therefore outstrips the food supply. He advocated marriages of prudence, and deprecated the existing poor laws, and the artificial stimulation of population.

Ricardo.—Ricardo (1772–1823) followed Smith as a rule, but treated the subject differently. He reasoned deductively from assumptions more or less arbitrary, and treated the conclusions as true; his doctrines were illustrated by reference to hypothetical cases, a practice extensively followed by his successors. His chief concern was with the distribution of the whole produce between wages, capital, and rent. The Ricardian theory of rent—the theory now generally accepted as correct—defines rent as that portion of the earth's produce which is paid to the landlord for the use of the original and indestructible powers of the soil; the rent of any land is the excess of the price of the produce over its cost of production on that land. As population increases, inferior soils are successively brought into cultivation, the cost of production on which determines the price not only of the produce of those inferior soils, but of the

whole supply (see below). The poorest land pays no rent; on any better, the rent is the difference between the cost of production on it, and the cost of that produced at the greatest expense. It follows that rent does not determine price, which is the same whether rent be paid or not.

This doctrine bears on that of wages and profits. The produce of labour is divided between labourer and capitalist, so that whatever one gains the other loses. As the price of food rises, so does the cost of the maintenance of the labourer, and therefore wages rise while profits fall. This falling is occasionally checked by new mechanical improvements, or agricultural discoveries. But though wages rise, the labourer does not gain, since the price of food-stuffs also rises; he can never for long earn more than a bare subsistence, according to the prevalent standard of comfort. For a more permanent improvement Ricardo falls back on the Malthusian device of limiting population.

After Ricardo, a number of less important writers, the *Epigoni*, including James Mill, M'Culloch, Senior, Torrens, H. Martineau, reduced the teachings of Smith and Ricardo to systematic form.

Early in the nineteenth century there was no body of settled economic doctrines; all was still a matter of opinion.

John Stuart Mill.—This state of things, so far at least as concerned the fundamental doctrines, it was expected would disappear on the publication by *John Stuart Mill* (1806–1873) of his *Principles of Political Economy* (1848). This work, which is a lucid explanation of Ricardo's economics, aimed at replacing in popular use the *Wealth of Nations*, which Mill regarded as obsolete in some parts and imperfect in all. From the important difference between production of wealth and its distribution—that while the former depends on fixed natural facts, the mode of the latter varies with the changing ordinances of society—he considers the problem of improving the existing modes of the distribution of wealth, and takes many steps in the direction of socialism. From the Ricardian enlightened selfishness, he passes gradually to an economic order founded on sympathy. As to economic "method," he is on uncertain ground, for, while in his earlier writings he affirms the à priori as the only method of investigating social sciences, he insists on the à posteriori ("inverse deductive") method in his *Logic*. Among Mill's disciples, *J. E. Cairnes* (1824–1875) was most prominent. He urged a rigorously deductive method, and left no room at all for induction. The work of these two writers made it evident that political economy, as they regarded it, was a purely hypothetical science, a long deduction from the assumption of an "economic man," who was influenced only by the desire of gaining the maximum of wealth with the minimum of exertion.

The Historical School.—The successors of Adam Smith, both in England and on the continent, followed more or less closely in his footsteps. No radical changes in economic method were made till early in the nineteenth century, when with *Comte* began the historical school which has already profoundly altered the character of the study, and will continue to exert a powerful influence on economic problems. Comte (*Positive Philosophy*, 1839) includes the study of all social phenomena, and their mutual relations in the science of "Sociology" (*q.v.*). Of this science, the laws may be statical, the laws of social existence, or dynamical, of social progress. His principal method is that of historical comparison. The fundamental principles of human nature are not to be neglected, yet from them can be foretold neither the general structure of human society nor its development. Direct observation is indispensable, especially in the case of dynamical laws on account of the accumulative influence of all former generations. The field of observation is the history of the world, including in this history contemporary facts. Applying these ideas to economics, it is seen that no true theory of the science can be formed without considering all other phases of society; economic phenomena cannot be isolated from the rest. The economic structure and development of society are ascertained not deductively from assumed premises, as the Ricardians affirm, but by direct investigation of history.

The *German* historical school (nineteenth century) applied to economics the conceptions of the historical school of jurisprudence. In the earlier period the chief exponents were Roscher, Hildebrand, and Knies. Later developments were due to Brentano, Schmoller, Held, Nasse, Rösler, Schäffle, Schönberg, and Wagner. All these insist especially on the need of a moral element in economic study, on the close relation between economics and jurisprudence, and on a conception of the State opposed to that of Smith. State interference is justifiable, not merely as a protection against violence, but wherever social ends can be most fully or solely attained through its means. Such cases, each of which is determined on its own merits, are intellectual and æsthetic culture, public health, protection of women, children, the aged and the destitute, security of labourers against accidental injury. This later German school has been powerfully influenced by the theoretic socialism of St. Simon, Fourier, Lassalle, Marx, Engels, &c. In practical economics it is midway between the *democratic socialists*, who would radically transform the whole economic structure of society through State interference, and the German *free-traders*, who, following Cobden, Say, and Bastiat, limit State action to the main-

tenance of order and the securing of individual freedom. The investigations of this historical school confirms Comte's view of the need for completely incorporating economics in a science of society.

The German influence was felt in Italy strongly and in France to a much less extent. In England the new ideas have steadily gained ground, aided by a growing dislike of the older system and a suspicion of the unsoundness of the "Manchester" policy of *laissez-faire*. The chief adherents to the new thought here were Bagehot, Leslie, and Jevons. *Bagehot* (1826–1877) declared that the system of Ricardo and J. S. Mill is true not universally, but only in those states of society where commerce is highly developed, and developed in the form taken in England; it does not explain the economic phenomena of early times or of other contemporary forms of society. The "economic man" of Mill and Cairnes is not only imaginary, as they had themselves shown, but could only act in a very limited and peculiar sphere marked by the rapid transference of capital and labour from one sphere to another. Bagehot attempted to reconcile the two opposing methods by assigning to the "abstract" method the explanation of modern advanced industrial life, and to the historical that of past economic phenomena, and of all the remaining part of present life.

Leslie (*Essays, Moral and Political*, 1879) also criticised the "abstract" school. The term "desire for wealth" is vague; as a matter of fact, men are impelled not by one, but by several economic motives, altruistic as well as egoistic. The à priori method cannot find the causes controlling the nature or the amount of wealth, or of the varieties in its distribution. Such causes are to be sought in history, and in the general laws of society. The wage fund theory of the abstract school is repudiated, as also their doctrines of the average rate of wages and of profits (save in a small and stationary world of commerce). The theory of cost of production as fixing price thus falls to the ground, and gives way to the principle that price depends on demand and supply. *W. Stanley Jevons* (1835–1882) similarly became more and more convinced that a true system could only arise through the overthrow of the Ricardian system.

The recent tendency of economics is thus to regard the science as a section of a larger science of society, with the other sections of which it is in an intimate and vital connection. Economic phenomena may be separated from the rest, but only provisionally. All primary social elements must be habitually regarded not as isolated from each other, but as in mutual interdependence. Growing in importance also are the high moral purposes to which the economic movement is subservient. The old doctrine of "right," the foundation of "natural liberty," is losing ground, and, through the pressure of practical needs, the doctrine of *laissez-faire* has lost much of its former importance. The State is more and more controlling operations making for public utility.

GENERAL THEORY OF ECONOMICS

Scope and Method.—Economics is a study of the motives which most powerfully influence man in his everyday business life. Most men are influenced there, as elsewhere, by motives other than economic, conceptions of duty, high ideals, and personal affections. The existence of these is not denied by economists; yet these are in the first instance neglected so far as they have no money measure, and a correction for the incompleteness of these premises is applied later on. The science constructed on this basis goes far beyond any other branch of the study of man, yet can by no means be compared with such exact sciences as mathematics and physics. Through the complexity and variety of economic phenomena, the conclusions of the science are true only within certain limits, which must be carefully defined. It is thus a science of tendencies resembling meteorology rather than astronomy, in the limited certainty of its predictions.

We shall therefore study the actions of men as individuals and in their relation to social life. We shall consider man not as a fictitious "economic man," but as he actually is, studying a whole class or nation, neglecting individual peculiarities, and ignoring all causes and effects not of an economic nature. If it is objected that society is an organic whole, and thus not capable of such treatment, that no set of human phenomena are wholly unconnected with, and therefore separable from any other set, it must be replied that this objection would be equally fatal to the biological sciences. But just as the brain may be studied without a physical separation of it from the rest of the body, so economic phenomena may be considered apart from religious and political motives.

The method employed will be twofold. By Induction, through observation and investigation of concrete particular facts, general laws or economic uniformities will be established.

But since this method can only state what *is*, and not *why* it is, it is to be supplemented by the more abstract, analytical method of Deduction. Starting not from particular facts but from general principles, *e.g.* that all men seek wealth, and seek it by the easiest methods, we may deduce what will happen under certain conditions from the operation of the principles assumed; the deduced results being afterwards compared with the actual facts. These two processes involve each other. The general principles from which deduction starts are themselves the result of observation. It is by induction that we ascertain how far the conclusions of the deductive method have to be modified in their application to actual facts. Further,

induction is invaluable to deduction in pointing out what needs to be explained, and in suggesting hypotheses to explain it. Induction is the more fundamental method in investigations relating to the production of wealth, to the increase of capital and population, to slave labour, and to the present proprietorship, where farmers own the land that they cultivate. The deductive method becomes the principal instrument when the facts to be investigated are complex and difficult. It is thus specially applicable to central problems of the exchange and distribution of wealth, to theories of value, wages, rent, interest, &c.

Wealth.—Wealth may be simply defined as consisting of "goods" which possess "utility," *i.e.* which satisfy some human want. Not all sources of utility are wealth, *e.g.* family affection and a good conscience. The additional quality to constitute wealth is potential exchangeability. This implies that the commodities are external to man, and that the supply is limited, so that man is prepared to give up some other thing in exchange. Wealth does not include personal qualities, nor yet, according to Marshall, service and other goods not capable of accumulation.

Demand.—We have called the power of satisfying a human want the utility of a commodity. As each particular want of man is limited, it follows that every increase to his stock lessens his desire to obtain more of it. Thus, while the Total Utility of a commodity increases with every addition to our stock of it, it does so at a decreasing rate. This is the Law of Diminishing Utility, and the Marginal Utility is the utility derived from the last small addition to the stock, the utility of that portion of a commodity which a person is just persuaded to buy. This last portion is termed the Marginal Purchase. It is evident that the marginal utility of money varies, for a sum of, say, a shilling, measures a far greater benefit to a poor man than to a rich man. When a man, to satisfy a want, offers something of value for an object, this is a Demand for the object; the price offered is the Demand Price. If the price falls, he buys more, for since the marginal utility decreases with the amount he possesses, he can be induced to purchase a greater quantity, at a lower price, though yielding less satisfaction (Law of Demand). There is no uniform relation between this fall in price and the increase in demand. And the price, we must note, measures not marginal utility *in general*, but that to each purchaser individually.

The notion of the *Elasticity of Demand* is important. Experience shows that the increased demand is not the same for all commodities for the same slight fall in price. Demand is said to be very elastic when a small fall in price causes a large additional quantity to be sold; slightly elastic for a small addition. The elasticity of demand varies with different incomes, so that each class of society should be considered separately, for the demand for a certain commodity may be very elastic for one class, and slightly so for another. When the price of a commodity is low relatively to the means of the class, the demand for it has little elasticity (*e.g.* salt, sugar), for the sale would not be much affected by a slight change in price. If the price is relatively *very* high, the demand is still only slightly elastic; thus a fall in the price of wine does not increase its consumption among the poorer people. If the price of the article is relatively moderately high, the demand for it has great elasticity; a change in the price of tobacco, meat, butter, &c., greatly affects the purchasing power of the poor. The demand for necessaries is evidently inelastic, for these must be had whatever the price. To distinguish between comparatively elastic and inelastic demands, each is measured by reference to a conventional "unity," at which point a fall in price produces such sales that the total receipts are unaltered. If the total receipts are increased, the elasticity is greater than unity; if decreased, less.

If a person has anything capable of several uses, he will so distribute it between these that the marginal utility is the same in each. For if the marginal utility were greater in one use than in another, he would gain by transferring it from the second use to the first. This is the *Law of Substitution, or Equi-marginal Returns.* These different uses may be either present or future, though, in the latter case, allowance must be made for the uncertainty of the benefit, and for the different value of benefits present and distant.

In general, a purchaser's satisfaction in the article bought exceeds that given up in paying its price. This excess, expressed in money, is called the *Consumer's Surplus;* the difference between the amount a man is willing to pay for an article rather than not have it, and the actual amount paid. We may then conceive of an aggregate surplus, with reference to a given commodity, made up of the surpluses of different individuals. Hence are suggested valuable practical ideas. Thus, in taxation, where the tax that wipes out least consumer's surplus is preferable, other things being equal, it follows that (1) things of which the demand is highly elastic should not be taxed, since a small tax largely reduces the consumption and the consumer's surplus; (2) commodities subject to increasing returns should not be taxed, for such taxation both of itself increases the price, and causes smaller consumption, which again means higher supply price.

The Agents of Production are Land, Labour, and Capital.

Land includes all utilities, whether found in land, sea, sunshine, rain, &c., over the supply of which man has no control, whose quantity is given fixed by nature.

Any increase in the capital and labour applied to land generally causes a less than proportionate increase in the produce from that land (*Law of Diminishing Returns*). This law refers to the *amount* of produce, not to the price, which may independently vary. It may, also, be kept in check by improved machinery and skill, in which case the returns may increase proportionately. Yet at length it becomes irresistible if the demand for produce increases indefinitely. Using James Mill's term, "Dose of Capital and Labour," each dose produces a less proportionate return. That dose which just repays the cultivator is called the *Marginal Dose*, and the return from it the *Marginal Return*. The marginal dose is not necessarily that last applied, but that on the margin of profitable expenditure.

On the other hand, every increase in the physical or mental vigour of a people increases man's productive power. And every increase of wealth tends to make a greater increase easier. Thus is produced a more highly developed industrial organisation, which adds much to the collective efficiency of capital and labour. Further, any increase in the aggregate of production generally lowers proportionately the cost of production. Hence while Nature's part agrees with the Law of Diminishing Returns, that played by man obeys the *Law of Increasing Returns*; an increase of capital and labour leads to an improved organisation, which increases the efficiency of the work of capital and labour.

The Balancing of Demand and Supply.—The market price of any commodity depends both on the demand price and the supply price. In every market, there is a definite demand price for each quantity of the commodity; the greater the quantity offered for sale, the lower the price purchasers will be willing to pay. Similarly, there is a supply price, that price which the holders of the commodity are willing to accept, which (in the case of decreasing returns) rises with the quantity. When, for any given quantity, the demand price exceeds the supply price, then the amount offered for sale tends to increase, since sellers are getting more than they need to induce them to manufacture that quantity. When the demand price is less than the supply price, the quantity of the commodity falls; and when both are the same, the amount produced remains also unaltered. This point is that of equilibrium; and the price is the market price.

Thus both utility fixing demand price and cost of production fixing the supply price, are factors in determining price. This doctrine, however, is quite accurate only for a stationary society; the demand and supply prices for various quantities are constantly being changed, and every change gives a new position about which the market price oscillates. As a rule, the shorter the period under consideration, the greater the influence of demand on value; the longer the period, the greater that of cost of production.

The above account makes the marginal cost of production (*i.e.* the point where a slight increase in production just repays its cost) a factor in fixing the market price, but does not explain the position of this margin, whether high or low. This depends on the causes controlling the size of businesses—the variation of the employer's expenses with increasing business. If the business grows from a very small size, marginal costs decrease at first, through division of labour and the use of machinery. But this fall is limited, as the business becomes too extensive for effective control under one employer. Marginal costs, therefore, begin to rise, and expansion of the business must cease at that point when the marginal expense equals the price, *i.e.* when the last addition no longer yields a profit on the cost of its production.

Monopolies.—The market price is, we have seen, fixed by the demand and supply prices, but in a monopoly, the quantity of the commodity offered for sale depends on the will of the monopolist. In a rigid monopoly, this control over supply is complete. The aim of the monopolist is to increase to its limit the difference between his expenses and his gross receipts; this limit, when reached, determines the output which will be aimed at.

Monopolies lead to higher prices, save in so far as they reduce the cost of production. When the demand is slightly elastic, a considerable rise in prices follows the creation of a monopoly, since in that case a small decrease in the supply raises the price considerably; with highly elastic demands, such rise in price is not so likely. Also, a great curtailment of supply will more probably be produced by the monopolist in those industries working under decreasing returns, for in the case of increasing returns, higher price would be accompanied by loss of the economies due to production on a large scale.

Monopolies may reduce prices where the cost of production largely consists of expenses of canvassing customers who would in any case purchase the commodity, though perhaps from a different firm, or where the real cost of production can be lowered by more efficient organisation.

Allied to monopolies are *discriminative* or *differential prices*, which imply some agreement between producers. Prices may vary according to the locality (through cost of carriage, or through tariffs), or the purpose for which the commodity is used (railway freights, higher for more valuable goods than for equal bulk of less valuable goods), or according to the person who buys. "Dumping" is a case of discriminative prices. This may assume several forms. It may be the export at low prices of the surplus quantity of output, which is not needed for the

home market (which is maintained at the same prices as though there had been no surplus). Or it may consist in excessive production for export to undercut competitors in a foreign market. But such substantial sales are necessary for this, and at such a cost, that this form of dumping is seldom worth while. For rather than lose all their plant by shutting down many established industries will continue to produce at a loss, provided that the price exceeds the actual cost of production apart from standing charges, and will be beaten only after a protracted and costly struggle.

In recent years, many voluntary monopolies have been created by the combination of different firms. Such agreements may leave to each firm much of its separate individuality (Kartels) or may completely destroy it (Trusts). Other forms of monopoly arise from the sole possession of certain natural products limited in quantity, from the protection of the law, as in the cases of patent and copyright, or from the peculiar nature of certain businesses which are most beneficially conducted as a social monopoly, *e.g.* lighting of a town.

Distribution.—We have now to consider the sharing out of the wealth produced by a community, and to explain the shares assigned to the labourer (wages), the employer (profits), and the capitalist (interest). We shall find that, broadly speaking, the same theory underlies all three, and that the differences are as to detail.

Assuming that all production is by groups of individuals and not by independent units, that each individual worker is equally skilful and willing, and each employer equally capable, we may imagine a certain community containing a fixed number both of employers and of labourers. Each employer endeavours so to regulate the relative amount of capital and labour he makes use of as to make his profit the greatest possible. This point is reached when an addition to either factor no longer produces more than enough to repay its cost; in other words, when the marginal worth equals what he pays for the last addition.

In the relation of demand to the wages of labour, we find that if all the available workpeople are employed at a wage previously fixed, which is below the marginal worth of labour, then the employers naturally seek more labour, in order to augment their profit. But since all workpeople are already employed, businesses cannot be extended, but wages are forced up by competition to the marginal worth. Thus the wages of labour are its marginal worth in production.

The influences on the side of supply fixing the remuneration of employed factors in production are not the same for all factors. Thus in the case of land, supposed equally fertile and well-placed throughout, the marginal worth varies according to whether it is fully occupied or not. In regard to the supply of labour, though the causes of the size of the population are obscure, we may say that the relative wages in many trades fix the supply of labour in them. Allowance, of course, must be made for differences in remuneration due to unhealthiness or unattractiveness of the calling, need of expensive training, or the risk of failure; nor do we infer that apart from these considerations, wages tend to reach the same level throughout the community, for the skill of workmen varies.

We conclude then that the wage is the amount at which equal quantities of labour will be demanded and supplied.

The actual earnings of capital are called *Net* Interest. What is commonly called "Interest" is really "Gross Interest," and includes recompense for unusual risks, or the earnings of management for a business. "Trade Risks" arise from fluctuations of the market, new inventions, or new competition. "Personal Risks" are due to the chances of unforeseen flaws in the borrower's character or capacity.

Capital may be taken as equivalent to wealth employed to bring in a profit. It is characterised by productiveness, so that the wealth consumed in production reappears in a fresh amount of wealth, and by the subordination of present desires to future enjoyment. Capital, therefore, excludes land, but includes all improvements made in it to adapt the earth to human usage.

Capital has a demand price and a supply price; these together fix the rate of interest at any time. The demand of a community for capital consists of a demand for production, and a demand for consumption, expended on goods to afford a direct sustenance to the workers. The supply of capital depends on people's power to save and their motives to save—the desire for interest, for provision against a rainy day, for a fund making possible a future advancement in life when an opportunity occurs.

The reward of the employer is his "Profits," but it must be noted that this term is ambiguous, being sometimes applied to mean gross interest, recompensing him for risks or work done.

Supposing an industry with a fixed number of employers, all working entirely on borrowed capital, and all equally capable, their businesses would be approximately the same size. Each man's remuneration would be the difference between the total receipts for output and the total outlay on rent, material, interest, and wages. This difference, of course, each employer endeavours to maximise. Now in the growth of a business from small beginnings, the increase of expenses at first falls, as we have seen, in proportion to the increase of output, through greater specialisation and use of machinery. But after a certain point, the increase of expenses rises proportionately. Hence every

employer develops his business to the point when the final addition to the expenses is equal to the price received for the additional output; in other words, when marginal expenses equal price.

But the number of employers is not, as we have just supposed, fixed. If, therefore, employers are receiving more than enough to induce them to devote themselves to the business, more people enter the industry as employers; the average size of a business is decreased, though the total output is greater, and the surplus for each employer diminishes till it is just sufficient to induce him to remain in the industry. And similarly, if the surplus is too small, employers begin to leave the industry, so that the remaining businesses expand and yield a bigger surplus. Thus the earnings of employers are fixed by demand—the surpluses of receipts over expenses, and supply—the numbers of employers willing to accept an income expected to amount to a certain sum.

The approximation of employers' earnings to a constant limit requires a much longer run than that required by interest or wages to reach their normal levels. For an industrial business is of slow growth, often enlarged under restrictions, and once established, continued till the plant is worn out.

Rent.—In ordinary use, this term stands for an annual charge made on land or buildings; in a broader sense, for the income derived from any things the supplies of which are limited and beyond human control.

If there be soils of different fertility in a country of scanty population, only the best land would be occupied at first, and no rent would be paid on it, for if rent were demanded, other plots would be cultivated instead. When the population has grown until less fertile land must be cultivated to produce the necessary amount of corn, this second land again commands no rent, and for the same reason. But since all the land of first quality is occupied, and only inferior land can be substituted for it, this land will pay rent, equal per acre to the difference between the produce per acre of the two kinds of land. Similarly for lands of still less fertility. When all the land of the country has been absorbed, and the population is still growing, even the poorest land bears a rent corresponding to the increased value of its produce.

The argument may be differently expressed, thus: The application of successive "doses" of capital and labour presently yields diminishing returns, as we have already seen. At length the return just suffices to repay the cultivator's outlay and work. This is the marginal dose, and may be applied either to rich or poor lands. On any land, the excess of the total produce of the actual dose applied over the yield of the marginal dose is the producer's surplus, and this usually becomes the rental value of the land.

Besides inequalities of fertility, inequalities of situation are a factor determining rent. In England, where the country is small and thickly populated, so that the producer is in close touch with his customers, this factor is relatively unimportant. But in new countries the richest land may lie uncultivated if not conveniently situated for markets, so that both factors may then be considered equally important.

It must be noted that rent does not enter into price, as a determining factor. High rents do not make high prices, but are the effects of them. The price is, as we have seen, determined by the cost of the marginal return. Thus the cultivators of more fertile soils are left with an extra surplus over normal profits, which, through competition, they are forced to give up to the landlord.

Quasi-Rents.—When the supply of certain appliances of production cannot be quickly enough adjusted to a changed demand for them, the net incomes from them are subject also to the foregoing theory, and may be called *Quasi-rents.* Consider a sudden demand for a certain kind of, say, textile fabrics caused by a change of fashion. The machinery employed in this manufacture yields for a time an abnormally high net income, greater than the normal profits on the capital invested in it. This income is a quasi-rent. Quasi-rents may be on appliances of many different kinds—not only on land, factories, machinery, but on business capability and manual skill; wherever, in short, there is any kind of differential advantages. Thus more efficient workmen tend to get larger wages than those whose efficiency is just sufficient to procure them employment. A quasi-rent differs from a true rent in this respect. If the latter ceased, those natural gifts which are free and imperishable would be undiminished, and produce just as before. But if quasi-rents from any class of appliances fell below normal profits on the capital and effort required for their supply, then those appliances would dwindle, and would *not* continue to produce. In long periods, however, there is time to adjust the supply to the demand. The shorter the period under consideration, and the slower the process of producing any instrument of production, the more truly is the net income from that instrument to be regarded as a quasi-rent.

Influence of Progress on Value.—The field of employment for capital and labour depends on the natural resources of the place, the social organisation and technical knowledge of the inhabitants, and the nearness to markets. The last factor is often underrated. Thus North America and Australia have become rich fields for the employment of capital and labour only since the growth of steam traffic, which brought the European markets nearer to them. New countries, however, chiefly owe their prosperity

to their power to promise to deliver goods at a later date, to their power to mortgage, in a way, their land at a high rate of interest. Hence the influx of capital, which makes the rate of wages very high. Later, the influx of capital is relatively slower, and wages tend to fall.

The influence of accessibility to distant markets on the National Dividend has been prominent in the case of England. For a hundred years, she has exported goods which are less costly the larger the scale of manufacture, in return for goods obeying the law of Diminishing Returns. But now, every improvement in manufactures spreads quickly over the Western World, so that by these improvements England gains little from exports to backward countries, and less still from those to manufacturing countries. She has gained extensively, however, from the cheapening of transport, which has replaced for the luxuries of a hundred years ago, low-priced food-stuffs, as the gains of foreign trade. Other influences tending to increase the purchasing power of the working man's wages have been the adoption of Free Trade by this country, and the development of the Mississippi Valley, and of Western America. Grain, meat, fuel, clothing, water, and light have all been cheapened by these causes or the use of machinery, in the nineteenth century.

Since the seventeenth century, the amount of accumulated wealth per head of the population has steadily increased. This has decreased the marginal utility of capital, and therefore the rate of interest. The spread of knowledge has produced a relative fall in the earnings of trained ability by increasing the numbers of "skilled" workmen. A growing need for quickness in grasping new ideas, rather than long experience in a trade, has lowered relatively the wages of elderly men, and raised those of women and young people. And on the whole, middle-class incomes are increasing faster than those of the rich; the earnings of artisans faster than those of professional men; of vigorous unskilled workmen than those of the average artisan.

A higher Standard of Life, implying increased intelligence, energy, self-respect, has increased the National Dividend and the wages of each grade. A "Standard of Comfort"—a mere increase in artificial wants—may be spoken of, which raises wages only so far as it involves a rise in the standard of life and of activity. A mere increase of wants, advocated by some as leading to an improved condition of the workers, can only raise wages through diminishing the supply of labour. This doctrine is favoured by those who believe that the pressure of population on the means of subsistence powerfully affects the rate of wages, but cannot be maintained by those who hold that improved modes of transport have minimised for the present the influence of the Law of Diminishing Returns.

Other writers have held that by reducing the hours of labour, labour is made scarcer, and therefore wages higher. In certain trades, causing excessive wear and tear on body or mind, shorter hours would lead to no permanent loss of National Dividend, since the increased efficiency of the workers would produce the same output in the lesser time. In other branches, employing expensive plant for only ten hours a day, a double shift of eight hours each would increase the National Dividend and therefore wages. In many trades, however, shorter hours would lessen the output without raising the worker's efficiency, and most of the resulting loss would fall on the workers.

The theory in question appears to assume that there is a fixed amount of work to be done, whatever the number of workers, and ignores that if work is scarce, there will be fewer new enterprises undertaken; that a decreased output leads to a decreased National Dividend and a lower wage.

Trade Unions.—A modern Trade Union, composed of workers of the same or similar trades, applies its funds, subscribed by its members to support its members who cannot obtain employment under Union conditions, to grant Provident Benefits to needy members, and to further its economic and political policy. This policy is, broadly, to secure higher wages and shorter hours, and healthy and safe conditions of work, and to provide a defence against tyrannical treatment by employers. A large Union is often composed of smaller associations, of which each manages its own affairs but is bound by the general rules of the central Executive; which strictly controls, also, the expenditure of Union funds.

Permanently to raise wages by lessening the supply of labour needs four conditions, namely: (1) there must be no easy method of production save that employed by the members of the Union; (2) the commodity must not be elastic in its demand, so that prices will rise considerably by a contraction of supply; (3) wages must be but a small proportion of the total expenses of production, so that a proportionate rise in wages will not greatly affect the price, and therefore the demand; (4) the other classes of workers, and the employers in the trade, must not be able to increase their share of the total produce by limiting the supply of their labour and capital.

The tendency of wages to approach a point of equilibrium where the amount of labour demanded equals the amount supplied, does not, in practice, always operate freely. A working man can seldom hold out long for a reserved price for his labour, and is thus compelled to accept a lower wage. In bargaining with an employer, even a combination of a thousand workers is a puny force if the employer of the thousand men be strong and resolute. Unionists contend that by organisation, workmen can

raise the current wages back to the normal level determined by demand and supply. Their chief instrument is the strike—which they admit is effective only when business is very prosperous; but even when the period of prosperity is waning, the threat of strike may succeed in preventing a fall in wages.

To this it has been objected—considering first a single trade—that constant threats of strikes lead to withdrawal of employers from the trade, in which employment declines; that though a strike at a prosperous period may increase wages, these increases would have come without it and have lasted longer. Considering next all the chief trades of the country, it is still maintained that any rise in wages at the expense of profits must promote the emigration of capital, and limit the enterprise of business men, so that a rise of wages tends towards its own destruction. Even if the National Dividend be not much lessened at once, yet the diminution is accumulative and progressive, so as sooner or later to reduce the supply of capital, and to lower wages.

The question thus becomes this, whether Trade Union action does actually lessen production, on the whole. The Unionists argue: (1) that they themselves join with the employers in making the working of the business run smoothly and certainly, that *e.g.* a fixed minimum wage is a convenience to an employer, reassuring him that no competitor is buying labour at a lower price; also, that in trades subject to severe foreign competition, employers and employed co-operate in arranging, through Boards of Conciliation, conditions of employment; (2) that their action promotes the efficiency of labour, which atones for any injury to the growth of production; they have given workers self-respect, strengthened their physique and moral character, and stopped a wastage of human lives in underpaid and "sweated" industries.

It is difficult to ascertain by direct observation from history the actual influence of Trade Unionism on wages. It appears that, other things being equal, wages are higher in trades having strong Unions than in those without. But it cannot be shown conclusively what the effect of Unions is on the aggregate of wages.

Socialism and Syndicalism.—The Socialist movement springs from a dissatisfaction with the existing structure of society, and aims at the creation of another in which will prevail a juster distribution of wealth, and more equal opportunities for the enjoyment by all classes of a rational and cultured life. The poverty problem, it is contended, cannot be solved without a radical upheaval of our economic structure. Wealth is becoming concentrated in the hands of a few, the wages of manual labourers remains stationary, the cost of living steadily rises. Thus the rich rapidly become richer, and the poor become actually as well as relatively poorer. Socialism affirms competition to be productive of untold misery and waste when applied to the production of wealth; by replacing it by co-operation, human productivity would be increased, and human existence made happier. Competition causes waste of capital and labour, and has led to the formation of Trusts and Kartels. These aim at economies in production and elimination of all competition, when prices and profits become correspondingly high. The Trust is an advance, in concentrating the control of industry, towards the stage when public ownership and control of the great industries is possible. This is the aim of Socialism; to replace the speculative, competitive method of production for the benefit of private capitalists, by a method of production by an organisation of national labour, with collective ownership of the means of production. "Capital" includes land, the instruments of production, and the floating capital necessary for production. Private landownership is condemned as economically and socially injurious; capitalism is attacked as placing the employed at the mercy of the employing class, making one man a means to another's selfish ends, and creating "the social evil of a non-labouring class."

Socialism is the economic side of a wider movement which in politics is Democracy, and in religion, the impulse to social service. It aims at realising its goal through a political democracy. In the Socialist State, such means of production as can be advantageously controlled by the community are made public property; private enterprise is encouraged if able to conduct a public service better than the State can. But there is no private capitalism, no exploitation of labour for the profit of others. The surplus value goes no longer as rent and profits, but benefits the community at large. State ownership of land and capital is the only way to bring this about, though taxation is a device which may be employed pending the full realisation of Socialist aims. Recent legislation has tended towards Socialism by a constant interference with the unrestricted private use of land and capital, by raising the standard of life through national education, old age pensions, insurance against sickness and unemployment, by the taxation of rents and profits to finance schemes of social reform, and by replacing private ownership of productive works and distributive services, *e.g.* railways and ammunition factories, more and more by State management. Beyond this, Socialist policy, pending the setting up of a Socialist State, demands an eight-hours' working day, a minimum wage for adult workers, free secondary and technical education, complete provision against sickness, the abolition of indirect taxation, and the raising of all the national revenue from unearned incomes and death duties, and State or municipal control of railways, telegraphs, water, and electricity supplies, land, mines, &c.

Socialists must be distinguished from non-socialistic Social Reformers, who believe that social evils can be abolished without altering, fundamentally, the economic structure of society. Socialism also must not be confused with Communism, Anarchism, Co-partnership, and Syndicalism, all of which aim at giving workers a greater share in the businesses at which they work, and all of which advocate the collective ownership of land and industrial capital. Of these, we give some account only of Syndicalism, through the attention it has attracted in recent years.

Syndicalism proposes that each industry shall be controlled by its own workers, that there shall be a federation of the groups, and that distribution of produce shall be regulated in the interests of all the producers by a general council of the federated trades. But this social organisation is purely industrial. The State is repudiated, and the present political methods and parties are condemned as not based on the strongest of all personal interests, *i.e.* the economic interest. There is not merely a passive indifference to the existence of the State, but an active hostility to it. The weapon of the Syndicalist is the general strike, for which it is easier to get workers to unite, and which is a great organising and educating force. Syndicalism resembles trade unionism in relying on industrial organisation, on close federation of unions, and on the strike. The latter, however, makes use of Parliamentary agitation to better social conditions, avoids strikes wherever possible, and prepares for them by amassing huge reserve funds.

International Trade.—Foreign trade is simply the working out in a larger area of the principles of division and co-operation. A more efficient employment is secured of the productive forces of the world when each of two countries produces, both for itself and for the other, the things in which its labour is relatively most efficient. The total produce is greater than if each country produced only for itself all the commodities it requires. Foreign trade also stimulates improvements in the processes of production, brings new objects to the notice of peoples, and promotes their intellectual and moral progress.

The motive of foreign trade is an increase in utility, in which both nations share. The possibility of this does not depend on the absolute cost of production of commodities in two countries, but on their comparative cost. Wherever the relative cost of production of two commodities is different in one country from that in another, it is to the advantage of each country to specialise in the commodity for which it is more specially fitted, and to import the other.

Since foreign trade is a process of barter, it follows that the total value of a country's exports is equal to that of its imports, neglecting cost of transport. That this equality is not apparent on examination of statistics, is explained in the case of Great Britain by the nation's huge carrying trade, repaid by the nations concerned in produce, by the investment of capital in foreign countries, the interest returning in imports, and by foreign travel, expenses of colonial officials, of soldiers, sailors, &c.

Free Trade and Protection.—Free-traders demand the removal of all artificial restrictions upon or encouragement to any particular industry. This implies freedom from taxation of raw materials, and of the means of subsistence, and that where foreign goods are taxed for revenue purposes, an equal tax must be levied on the home product. Protective tariffs, however, have been advocated either to bolster up some existing or newly-established branch of industry, or, on patriotic grounds, to make the nation self-supporting and independent, in case of war, of foreign countries. Home industries, it is affirmed, are supported by protective tariffs by excluding the foreign article and finding work for our own workers. Protective duties may also be imposed as a source of revenue. Through them, also, wages are kept up by excluding the products of foreign "pauper labour"; further, it is the foreign exporter who pays the duties, and a means is provided of punishing countries which decline to accept reciprocal terms.

Lesser advantages claimed for protection are that protected industries call into play the law of increasing returns, through the employment of larger capitals, and that new industries can be nourished which would otherwise be crushed by established organisations competing from abroad. Bounties are a form of protection, devised by mercantilism to encourage exportation; premiums are given to certain home industries to enable them to lower their prices abroad and thus secure foreign markets.

Money.—In early times, exchange consisted of barter, not between individuals, but between groups, the commodities being regarded rather as mutual gifts than as buying and selling. The idea of "money" began to arise when a commodity was desired as satisfying a need, and seen to be exchangeable for other things. Early forms of money were skins of animals, corn, shells, minerals, salt, and metals. To be used as money, any commodity must have a value of its own, which is high in proportion to its bulk, it must be homogeneous, so that any one unit of it has the same value, divisible without damage, durable, and its value constant and easily ascertainable. These conditions are best satisfied by the metals gold and silver. With the Hebrews and Greeks, currencies went by weight. Afterwards, their quality was indicated by a stamp.

At present the issue of coin is in the hands of the Government. In most countries, the expense of coinage has been borne by the owners of the bullion, but in England, no charge is made at the Mint, save that involved in the unavoidable delay. The charge on coinage is known as Seigniorage. As it raises the value of coins, it checks the melting of coins, which are more valuable by the amount of seigniorage than the uncoined metal.

Some economists advocate a double standard of currency (*Bimetallism*), arguing that, (1) within limits, the State can fix the value of the substances taken as money, since it is the quantity of coins and not the cost of production which fixes its value; (2) the ratio of the values of silver and gold (1 : 15½) being fixed all the world over by legal regulations, there would be no export of whichever metal lost value; (3) that a greater stability in the value of money is created; (4) and greater facilities for trade; (5) an increased quantity of money leads to an advantageous rise in prices. Most of these contentions are disputed by monometallists. In England, the sole standard is gold; silver and bronze currencies are merely token currencies, limited to small payments. Money discharges debts, facilitates exchange, through providing an easy comparison of values, necessary with increasing specialisation, and affords an approximate means of estimating the present value of future needs—a standard of deferred payments.

The value of money is often taken as the interest charged for the loan of it, but is more properly regarded as the purchasing power of money. Purchasing power, as regards money, is equivalent to price in the case of other commodities; the terms are convertible. The proximate determinant of the value of money is the equation between the amount in circulation at any given time, and the quantity of goods to be sold. But we must note that since money circulates with varying rates in different communities, we must take an average giving, in Mill's phrase, the average "efficiency of money"; also that it is the amount of sales, not of commodities, which is the determining factor, since the same article may pass through several hands before reaching the customer. We may then say that the value of money varies inversely as the product of the quantity and efficiency, the number of transactions being constant.

The ultimate regulator of the value of money is not chiefly, for short periods, the cost of production, since a change in the supply would only operate slowly on its value, but rather the relation between supply and demand. For long periods also, the cost of production has an influence difficult to measure.

The quantity of money required by a nation depends on the size of the population, the number of transactions, the efficiency of money, which varies with the habits of the people and facilities of communication, the systems of credit and banking, and the extent of hoarding, bartering, and payment of wages in kind. Thus we cannot say the absolute amount required, but, from an international point of view, the amount needed, after deducting the cost of transporting goods, is that which keeps a country's prices on the same level as those of the countries with which it trades.

Credit money consists in written or printed promises to pay actual coin—bank-notes, cheques, bills of exchange. All these rest ultimately on a gold basis. A bank-note circulates on the strength of the bank's credit, and is regulated by the Bank Charter Act, 1844. For every bank-note issued beyond a certain limit, specie must be held in reserve. This first portion of the issue, for which no gold reserve is required, is termed the "Fiduciary Issue," and it is assumed that all this proportion of the total issue will always remain with the public, and never be presented for payment. If the proportion of the fiduciary issue tends to rise beyond a point of safety, requests for loans are discouraged by the banks by raising the rate of discount (interest). Raising the bank-rate has a double effect. It makes men less willing to borrow, *i.e.* to get their bills discounted, and thus checks a tendency to overtrading. In the second place, those banks which allow interest on deposit will have larger sums tendered to them on account of the higher rate of interest. Thus less money is borrowed and more money is deposited when the bank-rate rises.

Taxation.—The subject of taxation is a department of the wider study of public finance, which deals with the revenue and expenditure of the State.

A tax may be defined as a "compulsory contribution of the wealth of a person or body of persons for the service of the public purse" (Bastable). Taxes may be direct, where the tax-bearer is the tax-payer (income tax), or indirect, when the immediate payer passes on the burden to others (production of commodities, customs, and excise duties). A revenue-tax must also be distinguished from a protective tax.

The Benefit theory of taxation affirms that the benefit of government to individuals varies with the amount of property protected, whence the tax should be imposed proportionately. The Faculty Theory advocates payment according to each man's ability as part of the organism of the State, ability to pay being measured by income. Proportional Taxation exempts a certain amount of income from taxation (in England, £160) and levies a proportional rate on the remainder. Progressive Taxation, however, favours an increasing rate with increasing incomes of those taxed; ability to pay, it is argued, increases more rapidly than incomes do.

Apparently the revenue required could best

be raised from the taxpayer in a single payment proportional to his income. This would be a *Single Tax* system, of which the best-known examples are the Physiocratic proposal of a single tax on land rent and the recently proposed tax on incomes. This system, which is never found in practice, has the merit of apparent simplicity, but, it is objected, is more easily evaded than a multiple system, irritates by its obviousness, and in practice would really be complex. The *Multiple* system, on the other hand, aims at bearing lightly at many points, heavily at none. Modern systems seek to avoid the defects of both single and multiple methods, and restrict taxation to a reasonable number of objects. The relative advantages of direct and indirect taxation must be discussed. The former is marked by facility and lower cost of collection, and affords information as to the exact amount paid by each individual (advantages also of the single tax), but the burden is obvious, the assessment of income and property is troublesome, and such a tax on the poorer members of the community is collected with difficulty and irritation. These weak points of direct taxation are the strong points of the other method; indirect taxes cause less irritation, reach all members of the society, are productive, and are collected at times convenient to the payer, *i.e.* at the times of purchase. On the other hand, consumption may be checked of taxed commodities, and injustice may be done through taxation of goods mainly consumed by the poor; the yield shrinks in times of depression, and, most important of all, serious loss may be caused by disturbance of industry.

Canons of Taxation.—Any good system of taxation must conform to certain Canons of Taxation, the most important of which were enunciated by Adam Smith. (1) All subjects of a State should contribute as nearly as possible in proportion to their ability. This, it is now coming to be held, involves progressive taxation for its realisation. (2) The form, manner, and quantity of every individual's contribution should be plain and not arbitrary. (3) Every tax should be levied at the time and in the manner most convenient to the contributor ("Convenience of Taxation"). (4) Taxes should be so contrived as to take out and keep out of the pockets of the people as little as possible above that which it brings into the public Treasury, *i.e.* its collection should cost little. Less fundamental principles are, to tax not capital but revenue, *i.e.* net revenue, and to preserve the source of the income which is taxed. Taxation should be stable; frequent changes in the system have a disturbing effect on contracts and understandings made on the supposition of a continuance of an existing system.

Local taxation provides revenue for the maintenance of local authorities. In its general characteristics, it resembles Imperial taxation.

A short account may here be introduced of the National Debt. This is the debt owing by a State to its subjects or to foreigners. In England, it began in 1692, with the borrowing of a million pounds, on the security of certain taxes, the yield of which was to pay the interest. The English national debt in 1914, before the war, amounted to about 700 millions sterling. It consists of two kinds of loans. The *Funded* debt is a permanent debt on which the State undertakes to pay interest, but which it does not promise to pay at any particular time. It is also known as *Consols*, because a number of loans raised at different times and rates were consolidated into a 3 per cent. stock. The *Unfunded* or floating debt consists of temporary loans repayable at fixed dates. These loans are raised for the convenience of the Chancellor of the Exchequer, who has often to meet payments before the taxes come in; they comprise Treasury bills, Exchequer bills, and Exchequer bonds.

The National Debt may be reduced by the Sinking Fund, or by the method of Conversion. The former in its earlier form was the surplus of certain parts of the public revenue set aside for the discharge of the public debt; but has sometimes consisted of fresh loans raised for that purpose. In the second method, a Government Stock at a given rate of interest is converted into one at a lower rate; the Government benefits by the diminution in the total amount of interest paid. In a third method, a portion of the debt is converted into a terminable annuity.

COURSE OF READING

The best introductory account of economic doctrines in accordance with Mill's treatise, is Fawcett's *Manual of Political Economy*. A more recent work, from the standpoint of the new school, is Marshall's *Economics of Industry*. A cheaper introduction to the science will be obtained through Chapman's *Elements of Political Economy*.

A useful compilation of extracts from the classical economists expounding the fundamental doctrines of the science is published in the "Scott Library" under the title *Political Economy Selections*.

Works of larger size are by Flux, *Economic Principles*, Chapman, *Outlines of Political Economy*, and Nicholson, *Elements of Political Economy*. After studying one of these, the student is ready to attempt Marshall's *Principles of Economics*, which is the standard treatise on those portions of economic theory with which it deals.

The development of economic ideas can be studied in Ingram's *History of Political Economy*, or Bonar's *Philosophy and Political Economy*.

Ashley's *English Economic History and Theory* gives a readable account, from the standpoint of the historical school, of early village communities of merchant and craft guilds, and of the development of mediæval economic theories. The *Encyclopædia Britannica* articles on "Political Economy" and "Economics" review economic thought in ancient times and in all the countries of Europe.

The classical works mentioned in the previous text may also be read, preferably in annotated editions, so that the student may see how far the views laid down are held to-day. Some of these works may be obtained in cheap editions, in some cases with introductory articles—*Wealth of Nations*, and *Leviathan*, in the World's Classics; Plato's *Republic* in Everyman's Library. A household edition of Mill's *Principles* is published by Longmans. In every case, it is advisable to have the text-book to hand.

Besides all the works on the general theory that we have mentioned, the student will find accessible a large number of volumes on separate economic topics. Many of these are of quite recent issue, concisely and attractively written, and presenting a thoroughly modern account of their subject. Among the most notable are, on Socialism, *The Socialist Movement*, by J. Ramsay MacDonald; *Socialism and Syndicalism*, by Philip Snowden; on Trade Unionism, *Trade Unions* (People's Books), and the Webbs' *History of Trade Unionism*. On Free Trade, there is an excellent volume in the Victorian Era Series by Armitage Smith, *The Free Trade Movement*; and on trusts, Longmans publish *The Trust Movement in British Industry* (Macrosty).

The student will keep abreast of modern economic thought by perusing the *Quarterly Journal of Economics*, the *Fabian Tracts*, and the special articles in the *Times*, *Daily News and Leader*, and other newspapers.

Lastly, since we have more than once emphasized the modern view that economic phenomena are but a part of a wider study of society, from which they can be only provisionally detached, it follows that the study of political economy requires a certain acquaintance with sociology, ethics, politics, and history. The student is accordingly referred to the courses of reading in these subjects in the present work. We add the following to the volumes therein mentioned: *Introduction to Social Philosophy* (J. S. Mackenzie), *Social Evolution* (Kidd), and *Social Psychology* (Baldwin).

F. W. F. Moir, B.A., B.Sc.

EUGENICS

EUGENICS was defined by its founder, Sir Francis Galton, as "the study of those agencies under social control, which may improve or impair the racial qualities of future generations." The idea of systematised and state-supervised race-regeneration is no nineteenth-century innovation. It is the master-secret of the great civilisations of olden time, and the extent of its practice is the measure of their durability and worth. Eugenics is an edifice old as the emergence of the provident mind of man, but ever gathering to itself new and wider foundations, ever rearing prouder and higher structures. It is a home of many mansions, and Modern or Galtonian Eugenics is, as it were, a vast mansion in the making, whose foundations are the modern sciences, whose corner-stone is the new science of Genetics (Breeding), and whose final altitude and dimensions no man can discern.

Francis Galton was a first cousin of Charles Darwin, and between the life-work and epoch-making discoveries of these illustrious kinsmen there is a close and instructive relationship. To Darwin we owe the scientific formularisation of the theory of Natural Selection, the theory of the differentiation of the living species by means of a selective death-rate; to Galton we owe the scientific formularisation of human or purposive selection, the doctrine of the amelioration of the human species by means of a selective birth-rate. The nucleus of both theories is Selection, for without Selection there can be no intrinsic progress.

Natural Selection is a non-moral process. Its chief weapons are privation and suffering; its victims are the superfluous products of the superabundant birth-rate which characterises life in all its manifestations. Nature never will regard the individual at the expense of the species, and weight of numbers produced was her earliest method of survival insurance. In the lower orders of life, plant and animal, the waste and destruction produced by the process of Natural Selection are enormous. For every living thing that, having attained to mature life, has facilities of propagating its kind countless millions at all stages of development are ruthlessly destroyed. A given environment is only capable of supporting a fixed amount of life, and every life that exceeds the limit is doomed to death. A life for a death is Nature's dictate. But production through reproduction is always greater than environmental demand, and the excess produced must be eliminated. According to the iron law of Natural Selection the least fit (*i.e.* the worst adapted to the particular environment) is the first to go, and this with total disregard to absolute individual worth, for fitness and worth are by no means synonymous, as the type of life that best thrives (or "fits") in a vicious environment proves. As we ascend the life-scale through the protozoa, invertebrates, vertebrates, mammals, finally to man, we notice coincident with, and in proportion to, the emergence of intelligence in the superior development the gradual lessening of the destructive processes and a stricter economy of life. The human birth-rate is lowest in Nature; the human death-rate is also lowest. How does Nature achieve this end? The economy is rendered possible by increasing parental responsibility, prolonging care of offspring, and extending the principle of social or co-operative protection. On account of such prolonged care and provision the development of a highly complex organism is rendered possible, by which the individual life is better safeguarded and equipped to face and conquer the hostile elements in his environment. It is by the extension and transmutation of these natural principles that Eugenics seeks to work. Its essence is Evolution made self-conscious.

The evolution of the mammalian order is the triumph of Natural Selection, but the order culminating in the family and social life of man has thus achieved the most effective means of restricting the powers of such selection. In man an intra-uterine period of nurture extending over three quarters of a year, a period of lactation of like duration, and parental provision and care extending over the greater part of the offspring's life, aided and abetted by social co-operation, make possible the long process of development of those phenomenal physical and mental powers which enable him not only to conquer and remould his environment, but to cope with and partially to arrest the cruel and blind destruction of Natural Selection in the human sphere.

The Arrest of Natural Selection.—Let us now consider the results of the arrest or reversal of Natural Selection which would ensue if the process continued uncounteracted in advanced human civilisation. In a highly civilised community

we notice that to a great extent the state shelters and protects not only the weak, but the worthless, the vicious, the improvident, abrogates to a considerable degree their struggle for existence; permitting them to multiply blindly, irresponsibly, to outnumber the worthy, the strong, the provident, who are themselves taxed and handicapped to support these social parasites. The unchecked prolongation of the survival preponderance of the unworthy must necessarily result in the deterioration of the race. To circumvent such deterioration and to further radical amelioration is the end and aim of Eugenics.

Ancient Eugenics essayed many remedies, conspicuous among which was infanticide. Thus in Sparta each infant born was examined by a board of authorities, who sentenced it to extinction if found to be of unsound constitution. By this means this ancient state long maintained a superlatively high physical standard of manhood and womanhood, but at the price of man's noblest endowment, the human soul humane. The protection of the weak by the strong is a ground principle of morality. The Spartan state remained barren in all the higher branches of culture, a barracks amid the beautiful homes of Greece. Not by foregoing his birthright shall man achieve his highest development.

Modern Eugenics offers a solution of the hitherto insoluble problem, by which is attained the same end in the sphere of man as the non-moral process of Natural Selection obtains elsewhere (*i.e.* the survival of the most fit). But Modern Eugenics achieves her ends by supremely moral and provident methods, and not at the price of morality and love. The solution offered is the selection of the worthy only for parenthood and the control of environment in the interests of such parenthood. The radically unfit is thus permitted to live to his fullest self-realisation; he commands our sympathy and protection, but he is denied the right to reproduce his kind. By such restraint we perform at once our duty to the individual and the race with the infringement of neither justice nor love.

Life is the product of the interaction of nature and nurture, of heredity and environment, of the inborn tendencies and the surroundings in which they operate. Both factors must be considered in any adequate and responsible system of Eugenics. For long the opinion has obtained currency that Education (Nurture) alone was sufficient. Improve the environment was the insistent nineteenth-century cry, and all else will be added unto you. But Education is literally and actually "a drawing out" of a given content, and if the content is nil, however perfect the process of Education the result is nil. No amount of Socrates' teaching could alter the innate flaws of Alcibiades' nature.

Nature and Nurture.—It is here necessary to draw a distinction between inherent, natural, or hereditary character and nurtural or acquired character. An inherent character, whether mental or physical, is an innate tendency which is the inalienable inheritance of the individual born, its existence being independent in its essence of extra-germinal condition and circumstance, and which is transmissible to the offspring by its bearer. To cite simple examples, hair, eye, and skin colour are all inherent and transmissible characters of germinal origin, while wisdom, muscular development, traumatic scars are acquired and untransmissible characters of nurtural origin. It must also be remembered that nature and environment apply also to the intra-uterine state, that all characters apparent at actual birth are not necessarily inherent; in other words, congenital does not always mean hereditary. Thus the malformation known as club-foot, though congenital, is not inherently germinal and hereditary, but is environmental, depending on local pressure in the pre-natal state, and is not therefore transmitted by the afflicted to the next generation. It will be readily seen that the correct classification of various characters as acquired or hereditary is of the utmost importance as a guide to mating and a fundamental factor in a system of Eugenics.

Eugenics and Heredity.—Eugenics is based on the scientific data of Heredity. The outstanding feature in Heredity is the fact that while like tends to beget like, each new individual exhibits a new departure which marks him as an individual entity. Thus Heredity involves two distinct tendencies—(*a*) continuity or persistence; (*b*) divergence or variation. The theory of Natural Selection involves no explanation of the phenomenon of variation; it merely observes its occurrence and registers its workings. Weismann has, however, offered us an explanation of the fact of continuity or persistence which has considerable biological evidence. He states that in embryonic development a residue of unaltered germinal substance contained in the fertilised ovum is reserved at conception to form reproductive cells for a second generation, *i.e.* simultaneously with the earliest development, the initial genesis of an individual of one generation material is set aside unused and unaltered for the development of reproductive cells to form the second generation, *i.e.* the germ-plasm (or essential reproductive matter) is continuous, and the child is contemporaneous with the sire. The individual may then be regarded as the guardian of a continuous stream of germ-plasm rather than the creator of the germ-plasm of the filial generation.

The variation tha is here discussed is a germinal modification transmissible to the second generation, and to be distinguished from

an environmental or acquired modification arising from habit or circumstance (*e.g.* muscular hypertrophy) which is not transmissible, and which we term an acquired character. Selection is the master-key to evolution, variation and continuity are its agents. The accumulation of variations through the ages, punctuated and governed by the eliminating action of natural selection, gives rise to new species, or in other words new species result from the selective action of environment l conditions upon the variations from the basal type which individuals manifest.

Natural Evolution.—In order to understand the end, aim, and scope of Eugenics some knowledge is required of the workings of natural evolution to which Eugenics is supplementary. The three factors involved in the process are Organism, Function, Environment; and the various theories are classified according to which of these factors is cited as the motive force. The earliest theories lay stress on function, and the chief exponent was Lamarck. According to Lamarck the differentiation of the species is the result of the cumulative transmission of functional modification. Changes in environment which brings about new requirements, new requirements necessitate new habits, new habits modify various organs, and continuous modification of organs transmitted from generation to generation results in the creation of new organs.

Take, for example, the time-honoured argument from the giraffe. Imagine a parental species with inconspicuous necks and inconspicuous fore-limbs depending for food on the foliage of trees. In course of time in a given area the food-supply within average reach becomes exhausted, and, argues Lamarck, hunger would cause the giraffes to stretch their necks and fore-limbs in search of the higher foliage. The next generation would profit by the exercise and consequential acquirements of the parents, and would be born with longer members. This would be repeated from generation to generation until the giraffe as we know him, with his exaggerated neck and fore-legs, was evolved. This is known as the Lamarckian theory of evolution. It is now generally discredited, as the facts of heredity give no warrant for the assumption—quite the reverse. The child does not begin where his sire left off, if he did, there would be no need for Eugenics. Heaven would long ago have come to earth.

In actual fact the child of the gymnast, unless he too is put in training, is muscularly no whit superior to the average child. The acrobat's son has to acquire co-ordination and balance like you or I. There is no royal road to the realisation of human perfection. Modern theories of evolution select environment or organism, sometimes both, as the motive force, in conjunction with the eliminating process of natural selection.

To return to the giraffe. Imagine again in a given area the parental species with moderate neck and limbs depending for food on the foliage of trees confronted with a scarcity of food within reach. The law of variation accounts for the fact that in each generation some of the animals born would have longer necks than the average, and some shorter. Obviously the animals with the longer necks would be able to reach the higher branches and survive while their short-necked brothers would be starved out. The survivors would mate with females who had also survived on account of the same variation, and thus in the filial generation the average neck would be longer. A continued food-pressure would bring about a further elimination and selection of still longer-necked abnormals. If we postulate indefinite time and a similar selection of long fore-legs on account of their survival-value we can finally credit the evolution of the giraffe as we know him. For this particular environment the chief assets of survival-value that make for fitness were length of neck and fore-limb. Similarly an environmental demand for long necks and bills among wading birds would produce, for instance, the flamingo.

This is roughly the accepted Darwinian theory. The vitalists, on the other hand, lay stress on organism, or the vital force within, urging organic change to meet environmental pressure, and ever striving after higher forms and more potent complexity.

Darwin demonstrated the amazing transformation that man had effected by applying the principle of selective breeding among domesticated animals and cultivated plants. Conspicuous are the results obtained in the stud-farm and in the case of cattle, sheep, fruit, and vegetables. In presenting his case for the evolution of the species he asks if man has been instrumental in differentiating such countless varieties in so short a time, what may not Nature have achieved with unlimited material and unlimited time at her disposal? But Eugenists ask us to draw yet another deduction from the successful production of improved varieties by man. They ask if this much has been achieved by the application of the principle of artificial selection in sub-human fields, what may not a corresponding application of artificial selection achieve in the world-wide field of the cultivation of the racial life? If Mendelian experimenters in our midst have, for example, increased the yield of certain of our cereals threefold, may not likewise the human harvest be increased ten- or a hundred-fold?

"But," object the critics, "this is a fatal and dangerous presumption on the part of man, a vaulting ambition doomed to overleap itself.

Moreover, the whole principle of artificial selection is false to nature and fact. We have at hand working before our eyes the time-honoured process of natural selection. We see its beneficent winnowing in our slums, where the unfit are cast out by the thousands. Let Nature revel in the merciful massacre of the innocents. Better let well alone." We reply that the conditions that prevail in the slums are anything but natural, and unfortunately such conditions not only destroy outright but irrevocably impair. Moreover, the awful sin of these impaired and blasted lives is visited upon the children unto the third and fourth generation.

Mendel's Discoveries.—Eugenics works upon the scientific data of heredity. Of modern discoveries in Genetics (the science of breeding) most momentous and most fruitful is the principle of gametic segregation formulated by Mendel, an Austro-Silesian abbot (1822–1884). His papers on segregation were read before the naturalists' society of Brünn in 1865, but their significance was entirely overlooked until their accidental rediscovery in 1900. De Vries in Holland, and Correns in Germany, had meantime arrived independently at somewhat similar results. The discoveries are of incalculable importance, and the principle of alternating generations when applied to problems in human breeding have already produced most encouraging results.

Mendel's research was chiefly prosecuted on pea-plants. The pea-plant (*Pisum sativum*) was selected as it has many varieties with particularly well-marked characters, and is readily cross- or self-fertilised. The experimenter crossed a tall variety of pea with a dwarf. The result of the hybridisation was a generation in which the peas were without exception tall despite the fact that one of the parents was dwarf. The character of tallness which thus prevailed Mendel called *dominant ;* the character of dwarfness in this generation latent, he called *recessive.* Self-fertilisation was allowed to occur in these tall crossed peas, and in the next generation there appeared talls and dwarfs in the proportion of three to one. The dwarfs of the generation were allowed to self-fertilise, and they bred only dwarfs. They were, therefore, pure recessives, always breeding true to the character of dwarfness. The talls of the same generation were also allowed to self-fertilise, and they bred two kinds—one-third of them (pure dominants) produced tall, but two-thirds of them (impure dominants) produced talls and dwarfs in the proportion of three to one. And so on in the next generation. The pedigree ground may be tabulated thus : Let T stand for the tall variety and D for the dwarf. Let T (D) stand for impure-tall (impure dominant). Let P stand for the parental generation (hybrid), F_1 for the first filial generation (inbred), F_2 for the second filial generation (inbred).

P				T × D			
F_1				T(D)			
F_2	25% T			50% T(D)			25% D
F_3	T	25% T		50% T(D)		25% D	D
F_4	T	T	25% T	50% T(D)	25% D	D	D

These Mendelian results are usually explained as follows : The gametes (or reproductive cells) of male and female fuse to form at conception a single union-cell called a zygote, which develops later into a new being. It is supposed that in cases of alternative or Mendelian inheritance dominance is represented in organisms which display it by a single gametic character. The corresponding recessive character is also represented by a corresponding factor in the gametes of organisms which display it. Those two factors do not blend, and when the two factors appear together in a zygote the recessive character always remains latent in the presence of the dominant. The zygotes arising from hybridisation of dominants and recessives are of three kinds :

(*a*) The dominant factor may be present in the gametes of both parents, the zygote is then called *duplex*, and always breeds pure dominant.

(*b*) The dominant factor may be carried by one gamete, the recessive by the other, in which case the zygote is called *simplex.* Such zygotes bear 25 per cent. pure dominants, 25 per cent. pure recessives, 50 per cent. impure dominants, *i.e.* bearing dominant and recessive, the latter being latent.

(*c*) Neither gamete may contain the dominant character but both the recessive, and then the zygote is called *nulliflex.* Such zygotes breed pure recessive.

Dominants and Recessive Characters.—The Mendelian law exemplified above is called the law of the segregation of pure gametes. Many human, animal, and vegetable characters have been found to conform to it, and it is therefore of incalculable importance as a guide to breeding. Thus in barley the presence of six-rowed ears as opposed to two has been found to be a Mendelian recessive character, the two-rowed type being dominant. The character has been segregated on Mendelian principles, and its uninterrupted continuance fixed. Immunity to rust in wheat has been similarly segregated as a pure recessive character, and its permanent presence guaranteed. Important as is the agri-

cultural gain of this Mendelian manipulation for cereals, vastly more important are the Eugenic predictions and interdictions regarding individual matings made possible by the discovery that certain hereditary diseases follow the Mendelian law. Thus a type of feeble-mindedness is now definitely known to be a Mendelian recessive, and when the pedigree of afflicted families for three generations is known correct prognostications can be made as to the germinal content of the members. Impure dominants in such families appear normal, but they can convey a fatal heritage to their children. In such families, therefore, those who are pure recessives and impure dominants should not marry. Pure dominants may marry, as they are absolutely free of the affliction although born of an afflicted stock. Thus Mendelism promises to furnish a guide of major Eugenic importance in problems of human crossing.

The Biometrical Method.—In hereditary cases which do not follow the Mendelian law, the biometric or statistical method is often instructive. Galton himself laid great stress on the efficacy of this method, but its results are now largely falsified by Mendelian discoveries. The relations Biometry establishes depend on the system of averages. The weakness of the method lies in the fact that from results obtained from averages no certain guidance or prediction can be furnished for individual cases, and in breeding the individual is all-important. Moreover, statistical method necessarily ignores contributory factors producing a given result, and thus often misrepresents the degree of their individual influence.

As an example of a statistical inquiry the research of Mr. Cyril Burt in the degree of hereditability of ability may be taken. The statistician selected three groups of children of the same age, the first group representing the sons of men of high intellectual attainments, the second group representing the sons of respectable middle-class tradesmen, the third group being drawn from Liverpool slums. These children were submitted to an intelligence test (a singularly unsatisfactory one at that), and the results obtained are offered us as a proof of the transmissibility of that illusive psychological quality. It is obvious that in this calculation a unilateral hereditary factor is selected and all the environmental factors ignored (*e.g.* education, feeding, clothing, sleep, &c.), although such factors have a very far-reaching influence on mental efficiency. Moreover, the statistician completely waived the maternal contribution in the boy's mentality.

Similarly, the biometricians compare the death-rate among married women between the ages of twenty-five and forty-five with the death-rate among unmarried women of like age. In the former case it is consistently lower than in the latter, and conspicuously so in the last decade. Many deductions are drawn, *e.g.* marriage makes for health; child-birth is an instrument of natural selection, weeding out the unfit in the earlier years of married life. But the point is ignored that marriage itself is an instrument of artificial selection preferring the healthier women to the unhealthy. The initial health-standard between the two classes is initially unfair. The conditions that make for a high death-rate in child-birth are not only eminently unnatural, but eminently avoidable, as Listerism proves. Moreover, when the death-rate in such cases was highest in the hospitals last century, it was quite undiscriminating in its ravages, attacking fit and unfit alike.

In our review of the evolution of the higher species we noticed four outstanding factors that made such development possible. These factors are selection, intelligence, parental care, and social care. Let these factors be continually before our eyes; they furnish a guide to procedure in Eugenic reform. It was also observed that in the sphere of human life the conditions of civilisation tend to abrogate and to a large extent reverse the process of natural selection of the fit. Without selection no progress is possible. In human states where the improvident and unworthy multiply much more rapidly than the worthy, if the conditions are such as increasingly to handicap and check the reproduction of the provident and the worthy, then not only is all racial progress paralysed, but retrogression is inevitable. It is the business of Eugenics to eliminate wherever possible all factors in the social life which contribute to reversed selection and hasten its disastrous and fatal consequences. And here we have not only the sanction of the teachings of Biology, but also the moving appeal of human history, for in every case the fall of the great nations—"Assyria, Greece, Rome, Carthage" of Byron's lament—is to be attributed to the relentless retribution of reversed selection, the dominance and the preponderance of the unworthy. The doom is sealed of states where reversed selection prevails, no matter how perfect their acquired characters—their arts, and their crafts, and their institutions. It is the inherent worth that makes for durability in all life, whether political or racial.

Warfare and Reversed Selection.—Is there palpable evidence of reversed selection in modern civilisation? Can retrogression be checked? These are questions of enormous consequence, and Eugenics furnishes an indisputable response. Modern warfare is an obvious instrument of reversed selection. In ancient times, when fighting was hand to hand and depended on individual strength and skill, war was often an effective means of selection of the fit. In modern times the recruiting officer selects the worthy in body and mind in the prime of their reproductive power to be mown down in millions,

while the unfit is left to enjoy his immunity and propagate his infirmities. The individual worth of the combatant is as naught before the diabolical powers of the gigantic ordnance on land and sea. Thus war not only affords immunity to the worst, but it destroys the best in their prime. It creates an unnatural disparity between the male and female population, fruitful of countless ills. It increases widowhood, which means unprotected motherhood and unprotected childhood with its vicious consequences in the next generation. The whole weight of the Eugenic argument is therefore in favour of peace. Again, any religion which encourages celibacy among its nobler adherents, which deprecates the divine function of physical parenthood, which accounts among the carnal lusts the sublime relation of man and wife, is an enemy to that power that maketh for good manifested in the universe, an enemy to the future and the heaven that is its promise. So in the life political any legal enactments, any taxation which embarrasses parenthood and family life among the deserving and provokes the evil of indiscriminate multiplication among the undeserving, are inimical to the racial weal. Misplaced charity, blind to the future and unsalutary in its dispensations, is an agent for the spread of social parasitism with its dysgenic consequences, and so, too, state correction, uneducative in its method, indiscriminating in its application. There is no gainsaying the Eugenic yea or the Eugenic nay. The Eugenic touch-stone is the final and infallible test of all religions, all ethics, all politics. Thus Eugenics ordains that we preserve Nature's law of evolution through selection, only we, being creatures of conscience, make our evolution conscious by selecting for birth, rather than by rejecting by death.

True Racial Betterment.—Let us now examine the auxiliary methods by which Nature has ennobled the creatures of her creation, that we, following her methods in the light of our reason and conscience, may further ennoble our natural ennoblement. As we ascend the life-scale we observe the marvellous transmutation of reaction into instinct, of instinct into intelligence, of intelligence into man's unique heritage of reason, and reason into the god-like omnipotence of genius. In mind, then, lies our superlative power; by this we are lords of earth and sea and sky; by this do we fathom the workings of Nature and offer our co-operation to further her ends. As intelligence emerges Nature denudes her creatures of weapons offensive and defensive, till the process is complete in the stark and awful nakedness of man. There are Eugenists, or rather pseudo-Eugenists, who advocate the cult of muscle for muscle's sake, who appear to envy the physical attainments of the rhinoceros, the elephant, and the mastodon, failing to see in the complete or partial extinction of these species the feebleness of muscle as an instrument of survival when confronted with the all-mastering intelligence of man. Eugenics therefore discountenances the cult of the physical except in so far as it is perfected and maintained as the servant of the mind or soul.

> "To man propose this test—
> Thy body at its best,
> How far can that project thy soul on its lone way?"

Yes, the physical is a medium, and as a medium of infinite value and worthy of meticulous care and attention; but it is not an end in itself. It is the temple of the future, to be swept and garnished against the advent of the god-in-man, that his spirit may fill it and justify and sanctify it.

Secondly, Nature has extended the principle of parental care, as a certain method of ameliorating her creatures. As we ascend the life-scale we witness the gradual apotheosis of the sacred principle of parenthood. The amœba, a unicellular organism of the simplest type, reproduces itself by fission. The parent is lost in the offspring. Reproduction is only achieved at the entire cost of individuality. In plant-life we observe the beginnings of sex, a dream-suspicion of the infinite possibilities of the urge of incompleteness, but the first-fruits of Nature's young love-dream, the seeds of strength in union, are entrusted to the unwitting wind of heaven or the careless insect in the sun, and in their millions perish, their life-cycle incomplete. The bee and the ant early learned the lesson of social co-operation, early appraised the queenly function of the mothering of their young, but cavalierly dispensed with the male's services except as a fertilising agent. Ascending the ladder of life, we arrive at the fish, exhibiting a greater physical complexity as an asset of survival value, but maternal care, observable in aquatic vertebrates, is comparatively rudimentary and the wastage of life in the making enormous. In certain piscine species there is actually an approach to combined parental provision.

So far we have been contemplating a world of life that cares at most for eggs, but when, ascending the scale of life, we reach the birds of the air we are in the midst of a world that cares also for its young. With the beginnings of co-operative parenthood the first dawning of moral life is visible, the protection of the weak by the strong even at the price of death. Such conduct makes possible a considerable diminution of the number of young produced at a birth. The fish produce their eggs in millions, and millions of children are beyond the reaches even of maternal love, but where two or three only are gathered together there is found Love in the midst of them. There is no sight more moving in its sacred beauty than the indefatig-

able sacrifice of the parent-birds for their callow young. Still higher is the mammalian order, characterised by the divine attributes of womb and breast, and culminating in man, the very son of God, whose destiny it is to transmute and spiritualise the great function of parenthood, which we see manifested in all living creation, to the end that it be to him the nurse, the guide, the guardian of his life, and soul of all his moral being. The monogamous union is the perfect instrument of race-culture, capable of ennobling and exalting the high privilege of fatherhood, protecting and safeguarding the sacred function of motherhood, and providing the precious helplessness of childhood with the best possible environment for the furtherance of its inborn heritage. The monogamous union is Nature's own institution; perfected only after æons of blind experiment and blundering failure. Any false prophets of Eugenics who advocate on any conceivable ground the adoption of human polygamy or polyandry are false to man's past, man's present, and man's future. The whole teaching of Biology is a plea for the lifelong protection of motherhood by fatherhood and the protection of childhood by both. Therefore Eugenics militates against the exploitation of child-labour and the participation of married women in industries to the detriment of their own health and their families' need. But the treatment of these ills is a social rather than a parental concern, and the bearing of Eugenics to social life is our next care.

Eugenics and Social Life.—The strength of union was an early discovery of Nature's. It was discovered in the days of the early invertebrates, and is exhibited in the extraordinary perfection of the social life of bees and ants. Eugenics claims to test finally all social institutions on the authority that society itself is but an instrument for the protection of the racial life. It is instructive to weigh and consider again the ant-heap and the hive, to consider their ways and be wise, for the anomalous aberrations perpetrated in the name of statesmanship would lead us to believe that man has forgotten the true *origo et fons* of the state, and deems it to exist for the protection of the golden calf, and not in the interests of motherhood and the life to come. The cynosure of the hive we observe is the queen, the motive of all this ecstasy of industry and activity is her protection and the protection of her young. We shall be nearer perfection when our statesmen forego their myoptic blinkings and cultivate the long vision which can focus the life to be in the life that is. It is the duty of society to protect the full cycle of life in the interests of the race, to foster expectant and nursing motherhood, infancy, childhood, adolescence, and maturity. State-appointed Listerian midwifery at every confinement is a first essential. Comfortable and sanitary homes are a second. Instruction in schools and homes in hygiene and life-principles is a third, and the creation of a universal parental conscience is a fourth. Eugenics is also uncompromising in its demands for the radical treatment of venereal diseases. Mothers and children must be safeguarded from the terrible ravages of this ghastly infection which cankers the very heart of our racial life. The conquest of Syphilis by Salvarsan is of extreme Eugenic importance. A plea is also made for the state to protect the future life from the hereditary and environmental curse of alcohol.

Elimination of the Unfit.—Eugenics, as seen, aims at the encouragement of parenthood. It also seeks to circumvent the actuality of unworthy parenthood.

Space is here too limited for a full discussion of the scope and methods of Eugenics in this eliminating process. Suffice be it to say that Eugenists urge the permanent care of the feeble-minded and insane, in order to prevent the further propagation of these calamitous infirmities. In other cases where the individual is apparently normal, but is liable to resuscitate a racial malady in his offspring, Eugenists urge the avoidance of parenthood. Such results can only be achieved by the development of a Eugenic conscience. Tuberculosis is now supposed not to be hereditary. It is, however, eminently infectious, and children of infected parents should be segregated.

Finally, Eugenics is above all a religion. It is an impassioned vision vouchsafed to the seeker after God. From his pillow, the stones of the earth, man sees again the wonderful ladder of life arise, where the angels of God ascend and descend. Above it the voice of God saying: "The land whereon thou liest to thee will I give it, and to thy seed; and thy seed shall be as the dust of the earth, and shall spread abroad to the east and to the west, and to the north and to the south, and in thee and in thy seed shall all the families of the earth be blessed. And behold I am with thee, and will keep thee in all places whither thou goest, and will bring thee again into this land, for I will not leave thee until I have done that which I have spoken of to thee." . . . And man, arising once more to labour in the waste and desert places against the advent of the fuller life to come, marvelling cries: "Surely the Lord is in this place, and I knew it not. This is none other than the house of God, and this is the Gate of Heaven."

The following Eugenic Institutions have been founded:

The Department of Eugenics, University College, London, founded by Galton. The chair is occupied by Professor Karl Pearson.

The Eugenics Education Society has its headquarters in London, but has branches throughout the Empire. Its organ is the *Eugenics Review*. Its object is the propagation of the Eugenic ideal.

A somewhat similar institution is the *Natural Council of Public Morals*, which founded the *National Birth-rate Commission* for Eugenic inquiry.

In America the *Eugenics Record Office*, under the directorship of Dr. Davenport, has made a speciality of Mendelian Research.

The French *Society of Eugenics* publishes the admirable *Eugénique*.

The corresponding society in Germany is the *Society for Race Hygiene*.

COURSE OF READING

The Methods of Race Regeneration, by C. W. Saleeby (Cassell & Co., 6*d*. net). This is a very simple and brief exposition of the aim and scope of Eugenics, popular in character but highly instructive and suggestive. It is an excellent primer of the subject.

Parenthood and Race Culture, by C. W. Saleeby (Cassell & Co., 7*s*. 6*d*. net). This admirable introduction to the study of Eugenics was supervised and appraised by Sir Francis Galton. It deals with a scientific subject in a popular and literary way, and will prove fascinating reading to the initiated and uninitiated alike.

The Progress of Eugenics, by C. W. Saleeby (Cassell & Co., 5*s*. net). This volume deals with the history and achievements of Eugenics during the last decade.

Eugenics, by Edgar Schuster (Collins, 1*s*. net). This terse and accurate little volume gives an unprejudiced review of the entire field of Eugenics. It is a scientific but highly readable treatise.

Hereditary Genius; an Inquiry into its Laws and Consequences, by Francis Galton (Macmillan and Co., 7*s*. 6*d*. net).

Natural Inheritance, by Francis Galton (Macmillan & Co., 9*s*.). These are two pioneer works on Eugenics, and should be studied by everyone aspiring to an understanding of the subject.

Heredity, by J. A. Thomson. Without a thorough knowledge of the principles of heredity, no real understanding of the Eugenic methods of race-regeneration is possible. This exposition of the subject is highly instructive and commendable.

Evolution, by J. A. Thomson and P. Geddes (Williams & Norgate, 1*s*. net). An understanding of the principles of Natural Selection is also a necessary preliminary to any serious inquiries into the principles of Eugenics.

The Scope and Importance to the State of the Science of National Eugenics, by Karl Pearson (Dulau & Co., 1*s*. net).

The Problem of Practical Eugenics, by Karl Pearson (Dulau & Co., 1*s*. net).

Nature and Nurture: The Problem of the Future, by Karl Pearson (Dulau & Co., 1*s*. net). These little volumes expound the principles of the statistical methods of inquiry into the problems of racial progress.

Man and Woman, by Havelock Ellis. This book deals with the sex problem, and throws many interesting side-lights on our study.

A. E. STIRLING, M.A.

III. LANGUAGES

PHILOLOGY

The literal meaning of the Greek word *Philology* is "love of literature and language," but except in continental universities the term is now rarely used in that comprehensive sense. Among the ancients this branch of learning was chiefly employed in interpreting texts and their meaning; and this was also considered the chief aim of philology throughout the middle ages. But since the rise and wonderfully quick growth of linguistic science in the eighteenth century, the term has been more and more narrowed, so that *Philology*, as generally understood to-day, occupies itself chiefly with the history of language, *i.e.* of its words, their forms, origin, and meaning.

This science is often called *comparative* philology, because its object is to trace the pedigree of words in the various cognate languages, and to establish by means of linguistic research the relations existing between families of speech. It is, therefore, not very different from *Etymology*, literally "the science of the true origin of words." The vague and often ludicrous notions as to the origin and ultimate connections of words entertained by the ancients and mediæval scholars was only possible because these early "philologists" lacked a proper insight into the nature of human speech and possessed no rigid scientific method. The chief reason for their failure may be discovered in the narrowness of their outlook.

To the Greeks only one language was worth studying—the Greek idiom—all other forms of speech being looked upon as barbarous and beneath notice. During the middle ages, the attention of learned men was concentrated on the three "regulated languages," Latin, Greek, and Hebrew; and the first two being closely related and the third totally different from the others, a comparison of their words and forms could not possibly lead to sound discoveries. It was not till people began to study the various branches of the Teutonic languages that progress on the right lines was made.

The Early Philologists.—The endeavours of men like Junius (d. 1671), Hickes (d. 1715), and the Dutchman, Ten Kate (d. 1731), in the field of purely Teutonic philology would most probably have resulted in the ultimate establishment of linguistic science on a firm basis, if this natural and slow process had not been accelerated by the sudden rise of the more comprehensive "comparative philology." The discovery of the relationship between the Indo-Germanic (or Aryan) languages completely revolutionised all linguistic research. Towards the end of the eighteenth century, chiefly through the works of William Jones (d. 1794), afterwards taken up and propagated by F. Schlegel, who was for a time the head of the German romantic school, European scholars became acquainted with the language of the ancient peoples of India, as contained in the venerable Vedas, and the younger Sanskrit sacred books, and the connection of most European languages with the Eastern idiom stood suddenly revealed.

This connection could only be explained by assuming that all Indo-European (or Indo-Germanic) languages—so called after their most Eastern and Western representatives—had sprung from some common source which, of course, had perished as a distinct idiom. The agreement is clearly exhibited in the inflexions and general structure of the sister languages, but it appears more striking in the vocabulary. It was impossible not to perceive that equations like the following pointed to a common origin of all the words involved:

SANSKRIT	LATIN	GOTHIC	ENGLISH
ajras (a plain)	*ager*	*akrs*	*acre*
saidim	*sedere*	*sitan*	*sit*
bhratar	*frater*	*brothar*	*brother*
yugam	*jugum*	*juk*	*yoke*
bhero	*fero*	*bairan*	*bear*
fods	*po(d)s*	*fotus*	*foot*
fitar	*pater*	*fathar*	*father*

The Original Meaning of Words.—Equations of this kind were at once discovered in great number. It was now possible to connect words

with their kindred in older and less modified languages, and in a great many cases their true and original meaning was definitely settled. Thus the English *saw*, the instrument, was connected with the root preserved in Latin *secare*, "to cut," and it was evident that the oldest saw was an instrument for cutting. This principle, however, was in the enthusiasm of the first discovery applied on too extensive a scale. Many words, it is true, may be traced back into the primitive Indo-Germanic language, but still remain isolated. This is true of most of the numbers, of many verbs expressing action, and of the names of relatives.

Many scholars were not content with this discovery, and attempts were made—and are still being made—to establish a further connection by means of some extravagant theory. The mode of reasoning adopted is well illustrated in the suggested explanation of the ultimate meaning of the words *brother* and *daughter*. The latter, for which the old Indian is *duhitar*, was connected with the root *duh*, "to milk," so that "daughter" was explained as meaning "milker," because her chief duty in the family, or tribal economy was, "to milk the cows." Similarly, *bhratar* was linked with *bher*, "to carry, bear," it being argued that the "brother" was the "supporter" of the sister in the first place. By this kind of loose reasoning the most astonishing results were obtained, and a complete idyllic picture was drawn of our primitive ancestors' mode of life.

The unsoundness of the method which leads to such results can easily be demonstrated. If it were applied to the interpretation of modern English words, one might, by disregarding the evidence of the older and cognate idioms, cheerfully connect *bard* with *bird* (from a common root ("to sing"), or *dog* with *to dig* (compare the digging habits of most dogs). If we are ever to get any further in the elucidation of the numerous isolated Indo-Germanic words, it will be through the discovery of another related language, or family of languages. It is true that attempts have been made to prove that the Semitic languages are related to the Indo-Germanic group, that both have a common origin. This theory, championed by Möller of Copenhagen and others, has, it is true, evoked considerable interest among philologists, but is still far from being generally accepted.

History through Philology.—The extravagant conclusions as to the ultimate meaning of many words were not the only excesses committed by the comparative philologists in the first flush of success. Until quite recently the idea prevailed that it might be possible to determine, by means of purely linguistic research, the geographical position of the country inhabited by the common ancestors of all Indo-Germanic peoples. A few examples may suffice to illustrate the mode of reasoning. The root contained in the English *mere*, "lake, sea" (Latin *mare*, &c.), and that of *salt* (Latin *sal*) are found in the Teutonic, Latin, Celtic, and Slavonic languages only: therefore the primitive Indo-Germanic race cannot have had a word for "sea," *i.e.* must have lived in the centre of the continent, and was, further, unacquainted with the use of salt.

But this is absurd—the roots of *mere* and *salt* may have been introduced into the languages that contain them after these had separated from the rest—or those that now lack them may have lost them before their speech was recorded in a lasting form. If that mode of reasoning were admitted, one might, with equal justice, claim that the Indo-Germanic primitive race did not know the use of "milk," for there exists no name for it that is common to all branches. Arguments of the above kind can only become valuable when supported by archæological and ethnographical evidence. It was Jakob Grimm who first uttered a warning against too hasty conclusions of over-sanguine philologists by "calling them away from the study of words to that of objects." This sounder method of connecting linguistic with archæological research has found a champion in Professor Meinger, editor of the periodical *Wörter und Sachen*, chiefly devoted to these problems.

Changes in Language.—In the foregoing paragraphs it has been tacitly assumed that language is continually changing. This fundamental fact need hardly be proved now, though it was never realised by the Greek philologists. If we try to read Chaucer in the original, we discover that his language deviates considerably from modern usage: not only is the spelling different, but the forms of words and their meanings are changed. There are many words in Chaucer completely unknown to us, while on the other hand he seems to lack expressions that we now consider indispensable parts of our vocabulary: old words are lost, and new ones take their places. And if we were to penetrate further into the past, and attempt to read King Alfred's writings, we should find that his English—though the lineal ancestor of modern speech—was altogether unintelligible. These changes—apart from the loss and gain of words—constantly at work in language may be divided into three classes according to their nature.

1. The *meanings* of words are changed because we are constantly extending or narrowing their scope. Civilisation advances and habits change, but the word very often remains although it no longer accurately describes the object or action to which it applies. Compare *pen*, originally = "feather"; *book*, now made of paper, is connected with *beech* because the

runes were carved into wood; *to write*=*to carve runes*.

Further, the number of figurative expressions is very numerous and constantly increasing, compare "to root out a habit," "the star of Rome was setting," &c. Early speech is always concrete—in subsequent stages abstract ideas are expressed in terms derived from concrete objects or physical actions: one talks of the "source of knowledge," and of a "bright" notion, or a "dark" plot. The emotions play a part in the transition from *nice*, with the original meaning of "stupid, wanton" (from Latin *nescius*, "ignorant"), to its present sense. On the other hand, a narrowing may be observed in the history of the word *fowl*, which term originally comprised all birds (which latter term was originally applied to young ones only—compare *brood*), just as *deer* was used for all wild animals in general. Changes of this kind are interesting to trace, and their history often throws light on the habits and customs of the people and the hidden workings of the human brain.

2. But not only are the meanings of words affected: the *pronunciation*, too, is changing continually. This process, though inevitable, is very gradual, and carried out by the speakers unconsciously. The reasons for this change—which is regular and uniform within definite communities of speakers—are difficult to discover. Very little can be said about this subject here. Language, as the expression of human thought, will change with the ever-developing mind of the human race; and just as the collective intellect of close communities is carried along by one uniform impulse in one and the same direction—in spite of the inevitable presence of advanced and conservative sections—so the accompanying changes of the common language must be equally uniform.

Professor Wundt, a leading authority on these matters, says, in his recent book on *Völkerpsychology*: "The question, how a nation in the course of centuries can change the sounds of a word beyond recognition (compare Anglo-Saxon *nigon*=*nine*, Latin *encaustum*=*ink*, &c., &c.), cannot possibly be answered in a thoroughly satisfactory and exhaustive manner. To do this, one would have to account for the nature and extent of all those changes which have taken place through external and internal circumstances in the entire intellectual and physical nature of the speaking community. All one can say is this: that such changes take place irresistibly, receiving little attention when they first begin to appear."

Letter or Sound Changes.—It was shown above, how, when the relationship between the Indo-Germanic languages was first discovered, lists of words were drawn up containing, for the purpose of comparison, the various forms adopted by certain "roots" in the different idioms. A close scrutiny of the corresponding forms led to the important discovery of the regularity of sound-changes. If, for example, one collects all the words that must have contained *p* in the primitive idiom, one will find that this "letter," or better "sound," is almost invariably represented by *f* in the Germanic languages: compare Latin *pater*—English *father*, *nepos*—*nephew*, *pes*—*foot*). In the same way, *b* is represented by *p*, *d*; *g* by *t*, *k*, and a similar regularity is observable among the other consonants as well as among the vowels.

Supported by these and numerous other observations of a similar nature, the philologists of the "seventies" (Leskien, Osthoff, Brugmann and others), arrived at the conclusion that "sound-laws," as they called these regular changes, were like natural laws, and did not admit of exceptions. These "sound-laws," however, are active for a certain period only, and confined to certain geographical areas; when they have run their course they disappear, their places being taken by new tendencies. Thus there was a law in primitive Germanic according to which every original *p*, if preceded by the word-accent, was changed to *f*; compare Aryan *sap-ta*, Anglo-Saxon *seofon*; later on it became the rule for *f* between vowels to turn into *v*, hence modern *seven*.

3. *Analogy* is the third factor in the constant transformation of language; it is sometimes more expressively called "group-influence," and may be described as the influence exercised by the members of one class or association-group of words upon another. The general tendency towards uniformity and the desire to simplify speech is chiefly responsible for analogical changes. Analogy affects both the sounds and the grammatical forms of words. Its most conspicuous results may be observed in the inflections. Thus there were in Old English many nouns which formed their plural in *-n*, e.g. *shoe*, *sun*, *hare*, &c., but only two of them, *oxen*, and the quite irregular *children* remain in modern English. The rest were attracted into the more numerous and powerful *s*-class. Again, *help*, *fare*, *heave*, *carve*, &c., originally formed their past tense and past participle by a change of vowel like *sing*, *sang*, *sung*, &c., but now conform with the majority of English verbs by retaining their vowels and adding *d* (or *t*). Analogical changes are constantly going on, and are particularly frequent in the language of children.

Dialects and Literary Idioms.—The old mistaken notion that dialects are merely debased forms of the standard speech has not yet died out. It is thought that the literary idiom alone can be "right," and that the dialects are "wrong" or "vulgar." However true this may be from a practical point of view, it cannot be

maintained when matters are examined historically. Each dialect is in itself as correct as the standard; it is often purer, because it does not contain so many foreign elements as a literary language is bound to absorb. Every standard idiom was at one time evolved out of a local dialect, and attained its pre-eminent position simply from political or literary, and other external reasons. When a nation achieves unity and a certain degree of civilisation, one of its dialects—often that of the capital, as in England and France—becomes the general means of communication throughout the whole state as the language of the court, the governing classes, religion, and literary endeavour. Such a form of speech, however, never completely severs its connection with the local dialects. The latter constantly exercise a strong influence upon its pronunciation in the various districts where it has penetrated, and enrich its vocabulary with new words and expressions.

Mixing, Borrowing.—Whenever two languages come into close contact, an interchange of forms and words takes place between them. The mode of contact may, of course, differ: it may be either physical or literary. If the former, it may be exercised by individuals travelling—merchants, missionaries, tourists, &c. In this manner, the earliest Latin loan-words in the Germanic languages were introduced by Roman itinerant merchants or by soldiers returning from service with the legions in various parts of the empire. Mixing on a larger scale is often effected by frequent intermarriage between neighbouring races, or between conqueror and conquered. It usually happens that the higher the culture of a people, the fewer words will be borrowed from other tongues. Thus, the Greeks rarely borrowed from Latin, whereas the educated Romans all acquired Greek, but despised all the languages of their other subject races, who in their turn, at least in the West and in Dacia, acquired the idiom of their rulers.

The Anglo-Saxons adopted hardly any words from the language of the Britons, but enriched their vocabulary on a large scale by the introduction of Latin and—after the Conquest—French words. The Normans, after settling in the North of France, speedily abandoned their native Teutonic idiom for the French tongue of their highly civilised subjects and neighbours. Similar conditions prevail in Eastern Europe, where the Slavonic races borrow from the German language, whereas the number of Russian, Polish and Czech words in standard German is extremely small.

A distinction is often made between two kinds of borrowed words: Foreign Words, which are easily recognised as such by their appearance, and Loan Words, which were introduced in earlier stages and completely assimilated. To the former class belong the numerous technical expressions in modern English derived from the Greek or Latin, as well as many words from Indian and African languages, and also names of objects recently introduced from abroad. The latter class is very numerous, and includes such common words as *plum*, *ink*, *chimney*, &c. It happens not infrequently that endings and peculiarities of syntax are borrowed and applied on a large scale. The *-er* of agent nouns, such as *baker*, *miller*, &c., was derived from Latin *-arius* at a very early stage; the diminutive suffix *-kin* is from the Dutch, whereas the use of *of* in *City of London*, *Kingdom of Scotland*, &c., is an imitation of the French usage of *de* in similar combinations.

The Origin of Language.—Speech did not come into existence like a stream rising from a source, nor was it invented like a mechanical apparatus. For it is wrong to assume that man was without language at any period, however remote and primitive. Speech must be explained as born out of man's *psyche*, by a slow and complicated, yet subconscious process. The primary cause of language-making is a desire for communication, the same that gives rise to the calls and warning signals of animals and the song of birds. Just as there are certain "natural" gestures and facial expressions common to all members of a community readily practised and understood by all, so there exist certain "natural" sounds and combinations of sounds used for the purpose of communicating one's sensations and thoughts. These man has in common with many animals. But a great step in advance, which separated human from animal speech, was made when these original and natural tones were conventionalised —when their use and application was extended to objects and actions connected though not identical with the ideas or sensations originally described.

Thus let us imagine, at the risk of being considered trivial, that the exclamation *bah* was used to express contempt. It might then be applied to a contemptible or obnoxious action or person, it might come to mean "to despise," or "to do wrong," or "bad man," "bad action," &c. &c. In short, *bah* would become a root used to form words, both verbs and nouns. Gradually it would, through inevitable phonetic change, lose its original phonetic form, and in its new shape be no longer expressive of the natural emotion of contempt. In short, the "root" would become completely conventionalised, with endless possibilities of change, both in sound and in meaning. Some philologists derive the Old English *feond*, "enemy" (modern English, *fiend*), from a root identical with the interjectional *pah* or *fie* (older *p* appears as *f* in Germanic)—but this is, of course, mere conjecture.

Imitative Words.—Another source of "roots" may be discovered in the habit of imitation: certain sounds are either produced by or regularly associated with certain objects or processes; these sounds are imitated and used to denote the objects or action in question. Words of this kind, usually called *onomatopoeic* (word-making), are constantly being formed; in the language of children they may be found in great numbers, as *bow-bow, puff-puff*, &c. To the most obvious of this class belong *cuckoo, owl* (compare Latin *ululare* "to howl"), *snigger, rustle, hiss, buzz*. Words like Latin *bibere*, which are sometimes described as "symbolical" words—the lip-consonant *b* symbolising the action of the lips when drinking—really form a subsection of the imitative element.

The above contains the present writer's own opinion on the vexed question of language-making. It may be of interest briefly to review the various theories—with their somewhat quaint names—mentioned in the discussion between Max Müller and Whitney.

1. The *bow-wow* theory, according to which the original roots were imitative sounds, so that, *e.g.*, *bow-wow* signified *to bark* or *dog*.

2. The *ding-dong* theory assumes a mysterious harmony between sound and sense. "Everything which is struck rings in a peculiar fashion, *e.g.* gold, silver, stone, &c. Man possessed a creative faculty which gave phonetic expression to each conception as it mystically thrilled through his brain." This faculty no longer exists in civilised man—it was lost when its object was fulfilled. This theory, worthy of the most mystic of German romanticists, was for a long time championed by Max Müller, who, however, abandoned it finally as untenable.

3. The *pooh-pooh* theory derives all words from interjections and ejaculations called forth by intense sensations—pain, pleasure, hunger, &c.

4. The *yo-he-ho* theory was finally adopted by Max Müller, who explained that "under any strong muscular effort—and one might add, intellectual and emotional strain—it is a relief to the system to let breath come out strongly and repeatedly. When primitive acts were performed in common, they would naturally be accompanied by the same sounds, which could easily become associated with the action performed, and serve as a 'root' to denote it." This would mean, that words like *to pull, heave*, and perhaps *swim* and *row*, were among the first to be "invented."

All this is hardly satisfactory; but before leaving this interesting subject, it might be well to quote the words of a more recent scholar, Professor Jesperson, who sums up his treatise on the origin of language as follows: "The genesis of language is not to be sought in the prosaic, but in the poetic side of life; the source of speech is not gloomy seriousness, but merry play and youthful hilarity: in primitive speech, I hear the laughing cries of exultation when lads and lasses vied with one another to attract the attention of the other sex, when everybody sang his merriest and danced his bravest to lure a pair of eyes to throw admiring glances in his direction. Language was born in the courting days of mankind: the first utterances of speech, I fancy to myself, like something between the mighty love lyrics of puss upon the tiles and the melodious songs of the nightingale. . . ."

Families of Speech.—With our present knowledge it is impossible to derive all languages from a common origin. Schleicher divided all known languages into three main classes:

1. *Isolating* languages, whose words express mere isolated ideas and not the relations existing between them. In short, there are no inflections. Chinese and other East Asiatic languages belong here. Compare Chinese *wân paó mîn*, "the king protects the people," with *mîn paó*, "the people is being protected."

2. *Agglutinative* languages, which express the relations by means of suffixes, prefixes, and infixes added to the simple roots. The Magyar, Finnish, Malay, and Bantu languages are said to belong here.

3. *Inflective* languages combine with the use of pre- and suffixes variation of the vowel of the root, for, according to Schleicher, "the essence of inflection is to be found in the differentiation of vowels." The Indo-Germanic and Semitic languages come under this heading. The change in the vowel of the root (compare *col-d-cool, sing-sang-sung*) is often called "gradation" (German *ablaut*), and must be explained not as due to a desire for a differentiation of meaning as Schleicher thought, but as the mere effect of a change of accent in the primitive language.

Schleicher's classification was generally accepted at the time, and still lingers in text-books of a semi-scientific character. But it is open to grave objections. Classes 2 and 3 do not differ in essentials, as the variation in vowels is not intentional but based on mechanical reasons of a purely phonetic kind. Further, it is wrong to say that in Class 1 the relations between the words are not expressed—because this is achieved by varying the position of words or the pitch of the vowels. The chief error committed by Schleicher and his school was that they confined their observations to the written form of language instead of investigating the living, spoken word. Had they done this, they would have discovered, for instance, that modern English exhibits characteristics belonging to all three classes: some words never change by taking endings, although they fulfil many functions, as *must, can;* others do take endings but never change the root-vowels, as

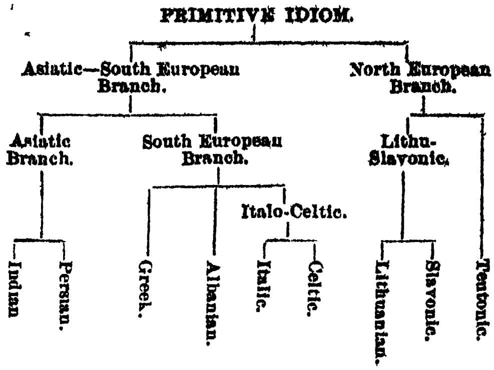
cat, plural *cats*; *ox*, *oxen*; *live*, *lived*; others both take endings and change the vowel, as *sings*, *sang*, &c.

Geographical and Ethnographical Families.—Schleicher's scheme was based on purely abstract considerations, and does not work in the application. The safest, if more elaborate method is to classify languages according to geographical and ethnographical families, by grouping together all those dialects that are demonstrably related to each other. On this basis, thirteen main types must be distinguished, each of which—so far as is known at present—may have had a separate and independent origin. Subjoined is a list of the thirteen families:

1. The Indo-European Family.
2. The Semitic Family.
3. The Hamitic Family.
4. The Monosyllabic or South-Eastern Asiatic Family.
5. The Ural-Altaic Family.
6. Dravidian or Southern Indian.
7. Malay and Polynesian.
8. Other Oceanic Families.
9. Caucasian Languages.
10. Remnants of Languages in Europe (Basque, &c.).
11. South African or Bantu.
12. Central African.
13. Native American Languages.

The Indo-European Family.—This is the most important, seeing that the chief representatives of modern civilisation are among its members. It should, however, always be borne in mind that an agreement in language does not necessarily imply a common racial origin. The Bulgarians, *e.g.* now speak a Slavonic language; but ethnologically they belong to the Ural-Altaic race—of which the Turks form part—having adopted the idiom of the Slavs, whom they conquered and absorbed at a remote period. We are here concerned with linguistic matters only.

Some of the Indo-European languages are more closely related to each other than to the rest. Thus a strong resemblance exists between the Persian (Iranian) and Old Indian (Aryan, Sanskrit) tongues; the Slavonic dialects have many peculiarities in common with the now moribund Lithuanian idiom; the Germanic branch agrees with the Slavonic in some points, with the Celtic in others, &c. &c. It would, therefore, be wrong to describe all these branches as the "daughters" of the primitive idiom. Schleicher attempted to explain the above-mentioned facts by drawing up a pedigree in which all the descendants of the primitive parent idiom are entered. He represented the latter as splitting up into two main dialects, which in turn break up again and again, a process that is still constantly going on. The subjoined table will speak for itself:



This classification was, for a long time, accepted as final. It can, however, not stand, as it fails to explain many agreements existing between remote branches of the pedigree. The Lithu-Slavonic idiom, for example, agrees with the Asiatic branch in the treatment of original *k*, which is changed to *s* or *ç* in both, whereas the other dialects retain the primitive sound in their older forms. It is wrong to imagine that languages, once they have separated from the common stock, develop, as it were, in water-tight compartments. Neighbouring idioms will always influence each other. The difficulty is overcome by rejecting the pedigree arrangement and adopting Schuchardt's and J. Schmidt's theory, according to which sound-changes travel from a certain point of inception in all directions, like a wave caused by a stone falling into the water, growing fainter and fainter in their effects until movement ceases altogether ("the Wave Theory"). The above-named scholars arrange the various branches in a "geographical" table, and thus are able to account for the agreements and differences in a more satisfactory manner. The Indo-European main idioms are distributed as follows:

Teutonic.
Celtic. Lithu-Slavonic.
Armenian. Persian.
Italic. Greek. Indian.

The most important among the Western dialects of the Indo-European languages are the Teutonic (or Germanic), the Romance (or Latin), and the Slavonic. The Celtic idioms, Irish, Welsh, and Gaelic, are leading but a precarious existence, the Lithuanian idiom is negligible, and modern Greek possesses little importance.[1] The Slavonic languages of the present day form three main groups: (1) Eastern (Russian); (2) Western (Polish, Wendish in Lusatia), Czech or Bohemian proper, Slovakish in Northern Hungary; (3) Southern (Slovenish in Western

[1] European languages that do not belong to the Indo-European group are the Magyar (or Hungarian proper), the Finnish and Turkish idioms which form part of the Ural-Altaic family, and the isolated, mysterious Basque tongue.

Hungary, Servo-Croatian, Bulgarian). The Southern Slav dialects are cut off from the main body by the Germans of Austria and the Magyars of Hungary—both occupying old Slavonic territory and largely mixed with Slavonic blood—and by the Roumanians on the Lower Danube. The latter are the descendants of the old Dacians, who accepted and modified the language of their Roman rulers. The Slavonic races are slowly emerging from a state of semi-barbarism, and the study of their languages is consequently receiving the attention of scholars and others more than has hitherto been the case. They are generally considered extremely complicated and difficult to acquire, and the most important among them (Russian) is written in a peculiar alphabet calculated to repel learners at the very outset.

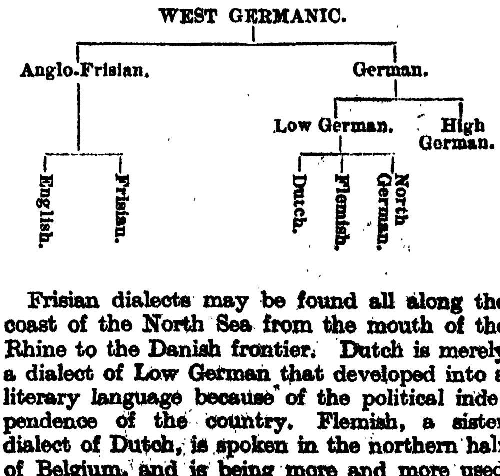
The *Romance languages* are descended from the old Roman or Latin tongue. They do not, however, spring from the highly polished and rather artificial idiom of the classic authors but from the so-called Low or Vulgar (better, Spoken) Latin of daily intercourse. There are found at the present day—proceeding from East to West—the following eight distinct idioms: (1) Roumanian, (2) Sardinian, (3) Italian, (4) Raeto-Roumanian (spoken among the mountains near the source of the Rhine in Switzerland), (5) French, (6) Provençal, (7) Spanish, (8) Portuguese. The ancestor of all these idioms—the spoken language of the Romans at the time of Augustus—was fairly uniform throughout the empire. How are we then to explain the existence of the present variety of the Romance tongues? The differences arose from two main reasons: (*a*) The Roman language was introduced into the various provinces at different periods and consequently at different stages of its development. (*b*) The pre-Roman populations modified the newly-received tongue each in a manner peculiar to its own character.

They also retained words from their old speech, though there are remarkably few of these. The sound-changes which transformed the Roman language into the various dialects were numerous and far reaching; they were carried out with complete regularity, but differed, of course, in the various provinces. In the later, or mediæval stage, most of the Romance idioms enriched their vocabularies by borrowing from other languages, notably from German. Spanish and Portuguese also introduced a considerable number of Arabic words during the Moorish occupation of the Peninsula, whereas Roumanian has absorbed numerous words derived from the surrounding Balkan languages. The Romance idioms transported across the Atlantic—American Spanish, Brazilian Portuguese, and Canadian French—bear no proved traces of influence from the native languages. All Romance dialects, and French in particular, contain a considerable amount of "learned" words borrowed at various times of the mediæval and modern periods from the classical Latin of the great writers. These learned words are distinguished by being less changed in appearance, as they were not subjected to all the numerous sound-changes which had been in operation previous to their introduction.

The Teutonic Branch is usually divided into three sub-dialects: (1) North Germanic or Scandinavian; (2) East Germanic or Gothic; (3) West Germanic. The first group split up into two sections at an early period: (*a*) West Scandinavian, comprising Icelandic and Norwegian; and (*b*) East Scandinavian, comprising Swedish and Danish. Of these four idioms, Norwegian has become almost extinct. Down to about a hundred years ago, Norway was ruled by Denmark, and the language of the dominant race was adopted by the bulk of the Norwegian people. The old native idiom is still spoken among the peasantry, and strenuous efforts are being made by a certain section of the people to restore it to its former position; but their ultimate success seems very doubtful.

East Germanic is the name given to the once powerful but now extinct races of the Austrogoths and Visigoths, the Vandals, Burgundians, and other tribes that perished in various parts of the Roman empire during the migration period.

The West Germanic branch is divided as set forth in the subjoined table:



Frisian dialects may be found all along the coast of the North Sea from the mouth of the Rhine to the Danish frontier. Dutch is merely a dialect of Low German that developed into a literary language because of the political independence of the country. Flemish, a sister dialect of Dutch, is spoken in the northern half of Belgium, and is being more and more used in literature instead of the imported French tongue. The fundamental difference between the High and Low German dialects is set forth in another section (GERMAN LANGUAGE, p. 304).

Before the primitive Germanic idiom split up into its three main dialect-groups, its con-

sonants underwent a radical change which is popularly called "Grimm's Law," but for which a much better name is "the first shifting of consonants." This shifting thoroughly differentiated the Germanic branch from the rest of the Indo-European languages. We can here furnish only a very brief outline of this important "law," formulated by Grimm in 1822 and emended by Verner in 1875.

First Series of Changes: *p, t, k* become *f, th, h*; Latin *piscis*, "fish"; *tu*, "thou"; *cor(d)*, "heart."

Second Series: *bh, dh, gh* become the corresponding voiced spirants whose subsequent history in the various dialects is too complicated to be treated here.

Third Series: *b, d, g* become *p, t, k*; Latin *labium*, "lip"; *edere*, "eat"; *genu*, "knee."

Grimm's Law describes only part of the numerous and highly complicated sound-changes that took place in the transition from Indo-European to Germanic. The number of sound-changes in the various languages and their dialects is extremely large, and can only be mastered after prolonged study.

COURSE OF READING

There exist very few books in the English language on the philology of the Indo-European languages, and the serious student of the subject will soon find that a knowledge of German is absolutely necessary for his work.

The general principles of linguistic science are admirably set forth by Jesperson in his little book called *Progress in Language*; see also the same writer's *Growth and Structure of the English Language*. Wyld's *Study of the Mother Tongue* contains chapters on general principles; the same applies to Sweet's *New English Grammar, Logical and Historical*.

The basis of all language study is Phonetics, the science of speech-sounds, for it should always be borne in mind that the spoken word matters much more than the written forms. Sweet's *Primer of Phonetics* may serve as an introduction into that science.

The best *brief* accounts of the various languages and their history will be found in the *Encyclopædia Britannica*. The Indo-European languages are exhaustively treated in Brugmann and Delbrück's *Grundriss der Vergleichenden Grammatik*; there is an English version of the first two volumes of the former edition. The Germanic languages are dealt with by various scholars in Paul's *Grundriss der germanischen Philologie*, vol. i.; the Romance languages in Meyer-Lübke's *Grammatik der romanischen Sprachen*.

A special branch of philology is the study of place-names. Most books on this subject are, however, totally untrustworthy guides. Taylor's *Words and Places* (Everyman's Library) forms interesting reading, but should be used with caution. An excellent introduction to this subject will be found in Wyld's *Place-Names of Lancashire*, and a shorter dissertation is contained in Mutschmann's *Place-Names of Nottinghamshire*. Weekley's *Romance of Names* deals with English surnames in a thoroughly sound yet entertaining manner.

H. Mutschmann, Ph.D.

THE ENGLISH LANGUAGE

HISTORY

PHILOLOGY tells us that the Indo-European or Aryan family of languages embraces Sanskrit, Persic, Greek, Latin, Teutonic, Celtic, and Slavonic. Aryan divides naturally into North Aryan (the Teutonic languages) and South Aryan (the classical languages).

Teutonic is divided into East Teutonic (Gothic and Scandian) and West Teutonic (Old Saxon, Dutch, Flemish, Frisian, English, High German). Hence we shall expect to find that English resembles German, Dutch, Old Saxon, Frisian, Flemish. And, since the common ancestor is Aryan, there may be a resemblance between English and—say—Latin. Compare Lat. *pater* with Eng. *father;* the only difference is that Lat. *p* becomes Eng. *f* and Lat. *t* Eng. *th* or *d* (O. E. *faeder*). So in Lat. *ventus* and Eng. *wind.* Lat. *v* = Eng. *w*, and, as in *faeder*, Lat. *t* = Eng. *d*, These changes of consonants are followed carefully in Grimm's Law and in Verner's Law.

English vowels also show relationship with Latin and Greek vowels. Lat *ā* (*māter*) becomes Eng. *ō* (O. E. *mōdor*): Lat. *ŏ* (*hortus, octo, nox*) becomes Eng. *ă* (*garden, ahtan* = *eight, naht* = *night*).

From these instances we can gather that North Aryan and South Aryan developed each on its own lines. Not only consonants and vowels were changed; meaning changed also. Aryan *sec* meant *follow:* from this Latin took *sequor,* I follow; but Teutonic specialised the word, and O. E. *seon* came to mean *follow with the eyes,* i.e. *see.* Thus, in *Beowulf, gang seon* means *go follow.* Again, Aryan *emuar,* to die, gave Lat. *morior,* I die; but Teutonic specialised it as *secret death by violence,* hence O. E. *morth* means *murder.* Yet the connection with Aryan *emuar* is often kept, and O. E. *morth* sometimes means *death.*

English is a descendant of Aryan, but it is a brother to other West Teutonic languages—German, Dutch, Flemish, Old Saxon, Frisian, and a cousin to the East Teutonic languages—Gothic and Scandian. The oldest piece of Teutonic prose is a version of the Scriptures in Gothic, a translation by Wulfila, who lived in the fourth century. In this we find Gothic words that differ but slightly from their equivalents in English, Old Saxon, Icelandic, German. The similarity between English and Frisian in phonology has led authorities to suppose that there was an intermediate stage of Anglo-Frisian.

Thus we see that English orignally came from a Teutonic stock. The Jutes, Angles, Saxons, and very probably the Frisians, when they invaded Britain, brought with them that part of the West Teutonic language which is termed Anglo-Saxon, or better, Old English. The language of the Britons was Celtic, but owing to the long sojourn of the Romans in Britain, the townsfolk probably spoke Latin.

Celtic Influence.—Why is it that Celtic did not influence the language of the Saxon conquerors? To-day there are only about a dozen Celtic words that were in all likelihood borrowed by the Anglo-Saxons, and the whole dozen can be challenged. The reason is that the invaders drove the Britons before them to the mountains of Wales and the Highlands and Islands of Scotland. The English word *Welsh* meant a *foreigner.* When a conquering army settles in a country the language of the conquerors is never mixed, but if the native language survives it is mixed. Englishmen had no inducement to learn the Celtic speech, but the Celts who remained as slaves or servants would gradually learn English. Words in Celtic and English may have been borrowed from Latin. Most Celtic words were borrowed late. *Pibroch* came from O. E. *pipe.* The Celts borrowed *pipe* and *piper,* and gave them a Celtic spelling; thus *piping* became *piobaireachd,* and English took the word back again with its Celtic spelling. *Brose* is simply the plural of *broth,* a Teutonic word.

The Britons were Christians, and after the English invasion we find Irish missionaries preaching to the conquerors. Any genuine early Celtic loan-words must have come through these missionaries—*e.g. dry,* a wizard; *bratt,* a cloak, then a pinafore (hence *brat,* a child); *luh,* a loch.

Early Borrowing from Latin.—It is difficult to tell what words the invaders took from the Latin spoken in the British towns. It has been said that the English borrowed the Lat. *strata* and called it *stræt* (street), but when we find Old Saxon *strāta,* Frisian *strēte,* Old High German *strāza,* we conclude that the English borrowed *strata* before they invaded Britain. Such words are known as "pre-Conquest loan-words" (note that this refers to the Anglo-Saxon Conquest of 449, not to the Norman Conquest of 1066), and among the list are *port* (Lat. *porta*), *pound* (O. E. *pund* from Lat. *pondo*), *mint* (O. E.

mynet, a coin, from Lat. *moneta*), *wine* (O. E. *win*, from Lat. *vinum*), *village* (O. E. *wic*, from Lat. *vicus*), *kitchen* (O. E. *cycen*, from Lat. *coquo*, I cook).

The Characteristics of Old English.—Old English is a simple language that gives the necessary words of life: it is easily pronounced and mostly monosyllabic. It has no abstractions, it deals with elemental concrete facts: *e.g.* relationship—*sweor*, father-in-law; *modor*, mother; *sweoster*, sister; parts of body—*eaxl*, shoulder, *fel*, skin (hence our *film*): natural history—*feoh*, cattle (cattle were used in exchange, hence our word *fee*); *sceap*, sheep; *vulf*, wolf; *boc*, beech: miscellaneous words—*etan*, to eat; *freond*, friend (from O. E. *freogan*, to love): words from Aryan gods—*Tuesday*, from the god *Tew*.

It will be seen from these examples that the O. E. vocabulary had words for obvious facts of environment; there is nothing to suggest mental or moral ideas.

Side by side with these common words we find a poetical vocabulary composed of stereotyped epic words. Teutonic poetry arose in the composition of spells, riddles, and songs. Later these were expanded into popular lays. There was no individuality in these lays: they were folklore, composed and recited by the community. We have an Old Saxon epic that uses the same phrases as the English *Beowulf*.

The old Norse sagas are lyrical; the artist procures effect by being brief and original. The Teutonic epic is entirely different. Instead of brevity, it has long tiresome descriptions; its method of emphasis is by variation. Instead of saying a thing sharply, it says it twice or thrice; in *Beowulf* we have—*They heard the sound of the horn; the horn sounded.* At one place *There they two were swimming* is repeated in different phrases five times.

The Teutonic epic came to be recited by a minstrel, and, no doubt, when he forgot a line he would mark time by repeating some tag. *Beowulf* is full of these tags or "kennings." They are generally alliterative, and mean nothing. When in *Beowulf* we read "I know not," it means nothing. Indeed many kennings, if taken as part of the story, would reduce the context to absurdity. King Hrothgar can do nothing to ward off the monster Grendel, yet he is called "the protector of Danes." Hrothgar, after visiting Grendel's den, says, "I know not where it is."

The wealth of variation in Teutonic epic is seen in many words for one object. For *sea*, we find *waeter*, *flôd*, *lagu*, *stream*, *sæ*, *geofon* (ocean), *waeter-stream*, *sæ-flod*, *swan-rad* (swan's path), *fisces bæth* (fish's bath), and many others. A civilisation that could describe the sea as "the swan's path" had some glimmerings of the picturesque.

Latin Influence.—We have seen that the English had Latin words before they left their continental home. The Romans left a few place-names, *e.g.* *-caster*, *-chester*, *-colonia* (the *coln* in *Lincoln*), and the English allowed these to stand. It was Christianity that brought Latin to England. Christianity came with the prestige of Roman greatness, and as a part of Roman culture. What appealed to the English was the tradition of a secular empire that the Roman missionaries brought with them. Religion to Teutonic civilisation meant politics. There was no spiritual conversion: the English simply added God to their other deities. They thought of God as a Teutonic chief, Christ as a great warrior; the Twelve Apostles as thegns; and Satan was the greatest warrior of all. We must not therefore expect to find words with any spiritual meaning.

The real influence of Christianity dates from 800, when the Church took education into its hands. The actual number of Latin words borrowed at this time was not large; the English preferred to find native equivalents for Latin religious terms. The word *archangel* means "high angel": the English had *heah* (high), and they invented the word *heahengel*. A *disciple* was a *leorning-cniht*, *Exodus* was *ût-færeld* (the out journey), a *centurion* was a *hundred man*, a *miracle* was a *wunder*, a *hermit* was a *wēsten-setla* (a dweller in the desert, *westen*), a *Pharisee* was a *sundor-halga* (a separate holy man), *music* was *swinsung-cræft* (song craft), *medicine* was *læce-cræft* (leech craft). These examples show that the English were timid of foreign words.

Scandinavian Influence.—About the end of the eighth century the Northmen began to raid the coasts of Britain. Gradually marauding bands began to settle in the North-East, and this settlement is known as the Danish Invasion. English at this time had various dialects, and naturally these of the North and East were most influenced by the Danish tongue.

The dialect of Wessex (King Alfred's dialect) remained unchanged: the dialects of Mercia and Northumbria became Anglo-Danish. The important thing to notice is that the literary language—the Wessex dialect—was outside the area of Danish influence. It must also be remembered that the language of the Northmen was a Teutonic language, and it had much in common with English. It is very probable that a Northman and an Englishman were mutually intelligible in conversation.

The Northmen were heathens; their civilisation was at a stage similar to that of the English when they invaded Britain in 449. Hence we do not expect words denoting culture; any Danish words introduced were democratic.

The Danes came as a hostile army, burning churches and books; wherever they settled, literature died. Consequently O. E. borrowings are few in number. It was only after slow

amalgamation that Danish appeared in any force. Scandian terms in Old English are different from those after 1200. Early loan-words were connected with the invaders' life, *e.g. cnearr* and *scegth* (names for ship), *hūs-carl* (a body guard). Most of the early borrowings died; English had quite enough terms for *ship* already.

The rule of the Danish kings brought new terms in law, &c. Law terms are *lagu* (law), *sacleas* (innocent), *hūsting* (meeting), *bryd-lōp* (marriage); war gave us *fylcian* (to arrange troops), *orrest* (battle); social caste introduced *eorl* (earl), *hus-bonda* (householder). Other words are *thriding* (third part: *cf.* the Yorkshire *Ridings*), *ceallian* (to call: O. E. word was *clipian*), *fellow* (O. E. *feoh*, cattle, and then money, and Scandian *lagu*, law). We have verbs like *hit, take, scream, skulk, scrub.* From Scandian come *they, their, them, hence, thence, whence.*

In many cases the O. E. form is retained in the literary language, and the Danish form survives in dialect. We have *true* and *trigg* (tidy), *church* and *kirk*, *chest* and *cist*, *leap* and *loup*. *Till*, instead of the preposition *to*, is a Danish survival in Scotland, and the termination *by*, seen in Whitby, is Danish also.

It is sometimes held that Danish was the cause of the Northern English dialects dropping their inflexions or terminations. No doubt the invaders, when they used an English word, would seize the stem and ignore the inflection. But the English dialects were shedding their inflexions long before the Danish Invasion. All we can say is that the Danish helped the process of dissolution.

There are certain tests for Danish words in English. In East Teutonic (Gothic and Scandian) these combinations of vowels *iew, aew, uw* are represented with hard *g*, while West Teutonic has *w*. Hence if we find a word like *trigg* in Middle English, where Old English has *treowe* (true), we conclude *trigg* is a Danish borrowing. In Scotland we have *big* (to *build* a house; the O. E. word was *buan*, to dwell). Other tests are the change of *ea* into *ou* (*leap* and *loup*); the Danish *sk* (*skill, bask, skulk*); the Danish ending *le* (*dazzle*).

It will be seen that the language of the Northmen had comparatively little effect on English. The law terms fell into disuse when the Normans brought over new law terms; the naval and military words already had English equivalents which they did not supersede. English did with Danish what it did with Latin—it translated it into English.

Middle English.—Middle English is the name given to the language of the twelfth to the fifteenth century. By the year 1500 modern English was in use. From 1100 to 1200 MSS. were written by scribes from many districts, and there is therefore much variation of dialect. After 1200 one dialect—Middle English—is the standard literary language. Between 1300 and 1500 the Northern dialect develops in its own way, and becomes Middle Scots. The southern dialects fall into decay and become non-literary. Language before 1100 is practically stationary so far as internal development is concerned; it is almost insusceptible to foreign influence. Latin words were translated into English; the Danes brought a few technical terms, and later influenced the literature of the north. In 1100 the language was but little in advance of the language of 500: it still depended on Teutonic material; it had the old grammar and structure.

Evolution of English did not begin until Norman influence was introduced; the Normans brought European culture to a race that had been cut off from intercourse with the Continent.

French Influence.—The Normans brought with them the Norman-French language. Although the Normans were Teutons, their tongue was a Romance tongue; it was a derivative of Latin. At the beginning of the tenth century Rollo, a Northman, settled on the coast of France and received territory from the French king. But in a hundred years the Northmen or Normans had adopted the language of the conquered Franks. This circumstance enables us to understand why Norman-French did not kill English as English had killed Celtic.

The Normans brought feudalism to England; before their coming, the idea of a vassal holding land in exchange for service to a lord was unknown. The Norman knight continued to speak Norman-French, which became the language of the court. In the course of time, Normans and English intermarried, and the distinction of race was lost, but the distinction of class survived. French thus became the mark of an aristocrat. Thus we find that Romance words introduced refer to the court, the military, the chase, and other aristocratic institutions. Thus we find the following Romance words introduced. From government: *crown, state, govern, government, sovereign, reign, chancellor, exchequer, people, nation.* From feudalism: *baron, duchess, vassal, peer, prince, heraldry, honour, glory, court.* From law: *judge, justice, jury, cause, summon, plea, defendant, crime, accuse, traitor, injury, penalty, property, heritage, damage, privilege, tenure.* From war: *army* (which did not displace O. E. *fyrd* and *here* for centuries), *war, battle, arms, armour, assault, banner, lance, officer, colonel, captain, lieutenant, sergeant, soldier, navy, admiral* (from Arabic *amiral*), *vessel, enemy, company, guard* (French had no *w*, hence English *w* became *gu*; Eng. *ward*=Fr. *guard*). From the Church: *clergy, sacrifice, pray, preach, sermon, service, trinity* (O. E. had *thrines*), *angel, virgin, saviour, saint, parish, miracle, feast, lesson, rule, tempt.* The Church also introduced words denoting moral

idea: *charity, chaste, grace, duty, pity, discipline, mercy.*

Norman-French.—The Normans brought in many words that pertained to their superior social status, *e.g. master, mistress, sir, madam, obey, command, rich, riches, poor, rent, money.* Their table habits are shown in *dinner, supper, toast, roast, jelly, dainty, soup, sausage, pastry.* The chase brought *scent, falcon, warren, quarry, leash, brace;* dress accounted for words like *costume, garment, apparel, tailor;* card-games gave *ace, trump, partner, cards, dice.* In French also were such words as *painter, carpenter, joiner, butcher, mason, table, chair, ornament, palace, manor, castle, mansion, choir, aisle, image, pillar, arch, colour, art, beauty.*

All these words suggest a culture superior to English culture. Many English words began to find French equivalents, but the foreign word did not mean quite the same as the native word. The native word is always more homely: *love* is nearer the human heart than *charity, amity* is colder than *friendship, lonely* is infinitely more expressive than *solitary.*

Normandy was lost to England in 1204, and after that date Englishmen began to study Parisian French. Norman-French was harder than Parisian French; the hard *c* in *carrion* or *caitiff* is Norman, but the *ch* in *church* and *chance* is Parisian.

We have thus two stages of French influence. Norman-French came first; it was the language of the court and the law; it was taught in schools. Then Parisian French became a cult in England; it was the language of French literature and the French court.

Speaking generally, French words were naturalised or rather Anglicised. The English had no compunction in taking a French word and tacking an English prefix or affix on to it. English were the terminations *-ly -ful, -less, -ness, -dom, -ship; court, beauty, art, dainty, duke, court* were French, but the English genius at once combined French and English and wrote *courtly, beautiful, artless, daintiness, dukedom, courtship.*

The terminations *-ry, -age, -ess, -ment* are French: the words *bake, mile, shepherd, endear* are English, but English stem was combined with French suffix to give *bakery, mileage, shepherdess, endearment.*

Many of the above are early formations, and the system of forming hybrids has obtained down to the present day. A familiar hybrid is the ending *ee* (from French *-é*); to-day we write *nominee, employee, trustee, devotee.*

The coming of French destroyed the ascendancy of the West Saxon dialect, and Middle English (the language of Chaucer) became the standard literary language.

Old and Middle English: *the Transition.*—From 1100 to 1250 the language is irregular in dialect and rate of change. The irregularity is partly due to the different degrees of emancipation from Old English. The North experiments more than the South; the Danish influence was felt most in the North, while the later French influence affected the South and Midlands most.

Middle English is the transition period between Old English and Modern English, and to understand it we must realise wherein Old differs from Modern English. Old English is a language of inflexions or case terminations. Latin is a language of inflexions. The Latin word *amabo* means *I will love:* thus where the Romans used one word we used three. When the Romans wanted to say *They will love,* they kept the stem *amab-* but changed the termination *-o* into *-unt,*—*amabunt.* Old English, like Latin, changed its endings to express different cases; *e.g.* O. E. *scop,* a poet (literally a *shaper* of verses) had genitive *scopes,* of a poet. *The song of the poet* or the *poet's song* was *scopes sang.* Where we say *of the poet* (three words), Old English said *scopes* (one word). But we retain this old genitive as a possessive case; when we write *the poet's song,* the apostrophe before the *s* shows that a letter has been omitted; this letter is the *e* of the old genitive *-es.*

We see that Modern English has lost its inflections. Dr. Sweet recognises three periods: the Old English period of full inflexions down to 1200; the Middle English period of levelled inflexions, from 1200 to 1500; Modern English period of lost inflexions, 1500 onwards.

Auxiliary words like *am, is, be, will, shall, would, do, can, must,* took the place of inflexions. The history of English is one of the widest freedom. We have forgotten origins: the *'s* is used where it cannot possibly have any direct relationship to the O. E. genitive *-es.* Thus we speak of *Alexander the Great's wars,* or even *the man that broke the bank's flight.*

The transition from Old to Middle English is evident by 1100: by that time the noun had a single form for all plural cases, and only two forms for singular cases; the verb also had reduced the number of its personal endings. By the fourteenth century the present plural of the verb *hope* was:—

Northern	*Midland*	*Southern*
We hopës	We hopen	We hopeth
You hopës	You hopen	You hopeth
They hopës	They hopen	They hopeth

We find a change in vowel notation. The O. E. *u* sometimes becomes *o* (O. E. *sunne*=M. E. *sonne*); O. E. *y* becomes *u* (O. E. *wyrcen*=M. E. *wurchan*); O. E. *u* becomes *ou* or *ow* (O. E. *scuras*=M. E. *schowres*=Mod. E. *showers*); O. E. hard *c* becomes *ch* (O. E. *circe*=Mod. E. *church*); O. E. *cg* becomes *gg* (O. E. *brycg*=M. E. *brygge*); O. E. *g* is softened into *y* (O. E. *geonge*=M. E. *yonge*=Mod. E. *young*); *a* becomes *e* (O. E. *beran*=M. E. *beren*=Mod. E.

to bear). The letter *e* began to be used for *u* and even for *an*; O. E. *nama* becomes *name*, *sunu* becomes *sune* (son), *withutan* becomes *withute*. Long *ā* in O. E. *stan* became *o*, *e.g.* *stone*, but was preserved in the North, *e.g.* Scot. *stane*.

The O. E. plural *-en* began to be superseded by *-es*; thus *housen* became *houses*. The old plural still exists in the Scottish *e'en*=*eyen* (the O. E. plural of *eye*), in *oxen*, and in *children*, *brethren*, &c.

A peculiar result of the Norman-French influence was the treatment of the guttural *gh*. *Night* in the Old English was *niht*, pronounced like the Scottish *nicht*. The *g* was introduced, no doubt to help the Normans to pronounce the *h*, for no Frenchman can pronounce a guttural. The *gh* was and is ignored by the Englishman; it is physically impossible for him to pronounce it. Hence we find English tourists in Scotland calling *Brechin*, *Breckin*, or *Auchtermuchty*, *Awtermawty*. The avoidance of the guttural *gh* is seen in the English pronunciation of *cough* ("coff"), *trough* ("troff," but Scot. "troch"), *enough* ("enuff," but Scot. "eneuh"), *rough* ("ruff," but Scot. "roch"), *dough* ("doe"), *sought* ("sot," but Scot. "soht"). Compare also Eng. *daughter* and Scot. *dochter*; Eng. *laugh* ("laff") and Scot. *leuch*; Eng. *night* and Scot. *nicht*. English has always avoided hard *g*; O. E. *fugol* became *fowl*, O. E. *dæg* became *day*, O. E. *hagol* became *hail*.

The Order of Words or Syntax.—If we translate word for word a passage of Old English, we find that the order of words is strange to us. The first lines of the *Beowulf* translated word by word runs thus: *Lo! we of the Danish kings in former days the glory have heard, how these æthelings valour showed.* We observe that the verb is placed at the end of a sentence, as it is in German. An inflected language does not depend on position; *Cæsar vidit legionem* means the same as *Cæsar legionem vidit*. We know that *legionem* (legion) is the object of the sentence, because it is in the accusative case. The order does not affect the meaning. Now take an English sentence; *James struck the horse*, and change the order to *The horse struck James*. Obviously in English a change of order involves a change of meaning. Old English itself kept a more or less fixed order, and the decay of inflexions in Middle English made a fixed order essential.

Chaucer.—A study of Chaucer's vocabulary will show all the changes noted above. Take the prologue to the *Canterbury Tales*.

Whan that | April | le with | his schow | res
swoote
The droght | of Marche | hath per | ced to | the
roote
And bath | ed ev | ery veyne | in swich | licour,
Of which | vertu | engen | dred is | the flour;
Whan Ze | phirus | eek with | his swe | te
breethe
Enspir | ed hath | in ev | ery holte | and heethe
The ten | dre crop | pes, and | the yon | ge
sonne
Hath in | the Ram | his half | e cours | i-
ronne, &c.

The most noticeable feature here is the prevalence of the final *-e*, but it is not always sounded. For example, if *Marche* (line two) is pronounced *March* the line scans well, but unless *swete* (line five) is pronounced in two syllables the line is not scanable. The loss of final *-e* in English may be partly due to the English habit of throwing the accent of a word back to the first syllable. In Aryan the accent was free, and it changed with each inflexion moving one step further down the road. Greek and Latin kept the Aryan system, and in our classical borrowings we find the moving accent, *e.g.*

fámily, famíliar, familiárity.
phótograph, photógraphy, photográphic.

English words did not move the accent, *e.g.*

lóve, lóving, lóvingly.
kínd, kíndness, kíndliness.

Naturally when the stem part of a word was accented in conversation, the ending would tend to tail off in a slovenly fashion.

Chaucer uses both methods; he will give to *Náture* the accent *Natúre* after the Latin-French manner. We have divided the above passage into feet in order to show how many words, now of one syllable, were dissyllabic then—*crop-pes*, *yon-ge*, *Ap-ril-le* (three syllables), *schow-res*.

In the sounds of words we notice a change. The *sc* of O. E. *scūras* has become the softened *sch* of M. E. *schowres*; O. E. *swōte* has become M. E. *swoote*; M. E. *drough* has lost the hard *g* sound of O. E. *drugoth*; O. E. *rote* has become M. E. *roote*; M. E. *swich* and *which* replace O. E. *swilc* and *whilc*; O. E. *geong* is M. E. *yonge*, another instance of softened *g*; M. E. *sonne* replaces O. E. *sunne*.

The French influence is clearly shown in the word *perced* (O. E. was *thyrlian*, to pierce, hence *nostril*=*nose thyrl*=*nose hole*), *veyne*, *licour*, *flour*, *engendred*, *enspired*, *tender*, *vertu*, *cours*.

The order of words cannot be accurately judged by reference to poetry; Chaucer (in line 8) puts *i-ronne* (run) at the end, but the position is surely selected to meet the exigencies of rhyme.

A quotation from Sir John Maundeville (1322–1388) will show the new order of words.

And some men clepen it Ganges; for a Kyng that was in Ynde, that highte Gangeres, and that it ran thorge out his Lond. And that Water is in sum place clere, and in sum place trouble; in sum place hoot, and in sum place cole. The seconde Ryvere is clept Nilus or Gyson: for it is

alle weye trouble: and Gyson, in the langage of Ethiope, is to seye trouble; and in the langage of Egipt also. The thridde Ryvere, that is clept Tigris, is as moche for to saye as faste rennynge; for he rennethe more faste than ony of the tother (from Galton's *English Prose*).

Here we are far from modern idiom, but we are also far from O. E. arrangement. This passage shows wonderfully little French influence; *clepen* (O. E. *clipian*, to call), *highte* (=called) *Kyng*, *hat* (O. E. *hat*) *water*, *cole* (cool), *faste*, *rennynge* (=running), *thridde* (=third), are all native words. *Clere* is from Old Fr. *cler*, from Lat. *clarus*; *trouble* is from Fr. *troubler*, from Lat. *turba*, a crowd; *second* is from Fr. *seconder*, from Lat. *secundus*; *ryvere* is from Fr. *riviere*, from Lat. *riparius*; *langage* is a French word from Lat. *lingua*. The *u* of *language* was inserted later, no doubt, to connect *langage* with *lingua*. In the Middle English period *u* was often inserted in imitation of French spelling; thus we find *kingue*, *finguer*, *guest*, *tongue*, and the *u* has survived in *guest* and *tongue*.

The last word of the quotation—*tother*—is interesting. In Scotland we still hear *the teen and the tother* for *that one and that other*. We have reverted to the O. E. *other*, but some words remain corrupted. *Apron* was originally *napron*; the confusion grew out of the phrase *a napron*.

Nickname was *an ekename* in Middle English; *adder* was *nædre* in Old English; *umpire* was originally *numpire*, from Fr. *nonper*, not equal.

Thridde is from O. E. *thridda*, three; in words of this kind *r* and *i* were easily interchangeable; thus we have *wright* from O. E. *wyrcan*, to work.

The Invention of Printing.—In the fifteenth century printing was invented. We shall examine a passage from Malory's *Morte d'Arthur*, which was printed in 1485.

Anone Sir Launcelot herd a voyce that sayd Launcelot goo oute of this ship, and entre into the Castel, where thou shalt see a grete parte of thy desyre. Thenne he ran to his armes and soo armed hym, and soo wente to the gate and sawe the lyons. Thenne sette he hand to his suerd & drew hit.

Here we find that many inflexions have disappeared, and that the grammar is almost modern. *And soo armed hym* is the only archaic idiom.

The establishment of the printing-press in England settled the supremacy of the Midland dialect as the literary language. Printing created a standard, and writers of different localities conformed to the standard, just as rustics who talk dialect to-day try to write idiomatic English in their correspondence.

Distrust of the Vernacular.—By the sixth century A.D., Latin had ceased to live, but it continued as the language of the Church, diplomacy, and the cultured classes. The great Italian poet Dante struck the death-blow. Before his time the writers of the earlier Renaissance despised the vernaculars as vulgar and corrupt mediums. Dante defended the vulgar tongue, but he used it because he was writing what he called comedy; he purposed writing a tragedy in Latin, thus showing that he did not trust the vernacular entirely. At the end of the sixteenth century, Italy had academies—the Florentine and Dellacruscan—which existed to champion the vernacular.

In France we see a similar movement to make the vernacular the literary speech, but there the desire to use Latin was never so strong as it was in Italy.

In England, as we have seen, the vernacular underwent a long period of influence from French and Latin. Old English compounded easily, but Middle English lost the power to compound, and borrowed ready-made words. Caxton attacks Latinising, and says that the standard of ordinary speech must be taken from ordinary people. And by controlling printing, Caxton had a wide effect. In the sixteenth century, English began to borrow from every language it came in contact with, and Latin became the medium of the Universities only.

Naturally we find distrust of the native speech in scholars. Ascham in 1545 states that it is easier to write *Toxophilus* in Latin or Greek than in English. Thomas More writes his *Utopia* in Latin; Bacon puts his *Essays* into Latin so that they may survive; Hobbes, when eighty-five, writes his autobiography in Latin verse. The Latin inscriptions on tombs, church windows, and other objects meant to last, show the old fear of the native language's being but an ephemeral thing.

At the Reformation Old English began to be studied. Old English literature was essentially democratic; it was written for the people. And as the object of the Reformation was to take education from the few and give it to the many, Old English works were respected. In the destruction of the monasteries, the Old English manuscripts were preserved. The services of the Church were changed from Latin into English, and the Bible was printed in the vernacular.

Thus until the seventeenth century we have a vernacular impulse and a classical impulse side by side. Every writer was experimenting with words; the scholars used what Wilson in his *Arte of Rhetorike* called "ink-horn terms," *i.e.* strange foreign words fished up from the bottom of the inkhorn; the popular preachers introduced many colloquial expressions into their sermons; a poet used so many archaic words that Ben Jonson remarked that "Spenser in imitating the ancients writ no language." There was absolute freedom; Shakespeare uses adjectives for verbs, nouns for verbs, nouns for adjectives, double negative and comparatives.

Between 1530 and 1560, roughly, most writers condemn English as a literary medium, but between 1560 and 1600 there is a strong reaction. Writers all regret that English borrows so much from other tongues, but admit that it must do so. The translators, Florio, Golding, and Stanyhurst admit no inferiority of English, and Sidney says it is equal to any other tongue in the world.

At the end of the sixteenth century, then, the vernacular was an established institution. Writers accepted it, but they were afraid of its becoming corrupt by over-borrowing. We find modern English words condemned by purists of the late sixteenth century, *e.g. ponderous, antique, despicable, homicide, prodigious, retrograde, clumsy, strenuous, conscious*. Other words objected to at that time have not survived, *e.g. ventosity, obstupifact, dominators* (lords).

The seventeenth century, the period of dictionaries, believed in frank borrowing, and most writers on the subject boast that English is better than any other tongue. But the idea that English was being corrupted still held ground, and we find Dryden and others advocating the institution of an Academy of Latin scholars to fix the language.

Fresh French Incursions.—The Restoration of 1660 brought French influence back to English language. French helped to break down the involved sentences of Milton and Browne. Many French words were borrowed, but were not naturalised. We saw that French words borrowed from the Norman-French and Parisian French took English accents and pronunciations; the French was hard in Middle English, *e.g. church, chance, charge*. Modern French words beginning with *ch* take the soft French sound; hence we can tell that *chef, champagne, chic, chaperon*, are modern loan-words. *Chivalry* is an old borrowing, and according to age the *ch* should be pronounced as in *church* or *chair*. But since popular usage favours the pronunciation *shivalry*, it is pedantic to insist on hard *ch*. Many other words came in with the Frenchified court plays; *e.g.* Dryden uses *chagrin, levee, foible, penchant, apropos, ballet, maladroit*.

The eighteenth century was a time of longing regret for a Golden Age in the past. Writers of 1700 looked back to works of 1650 and said "English was pure then"; but in 1750 writers looked back to 1700 and said the same thing. Landor pitched on 1780 as the "Golden Age" of English language; Matthew Arnold looked back to Landor's age; and to-day some of us look back to Arnold's time and say "Language was fine then."

Swift, Bentley, Johnson, Hume, Beattie, Landor, Arnold, and Churton Collins all believed that language could be made stationary—that a standard could be fixed. Johnson wrote his *Dictionary* in order to fix the language, but before the work was finished he saw that the language could not be fixed. What these men did not understand was that to be fixed a language must die. Latin is a dead language; it can never change.

In 1710 Swift urged the editor of the *Tatler* to circulate a list of bad words. He condemns abbreviations like *phiz* for *physiognomy*, or *mob* for *mobile vulgus*, on the plea that there are too many monosyllables in the language already; he objects to invented words like *kidney* or *bamboozle*, and to polysyllables like *ambassadors, preliminary, speculation, operations, communication*—all words introduced from the War of the Spanish Succession. It is obvious that Swift's opinion counted for nothing.

In 1712 Swift sent a letter to the Earl of Oxford proposing to found an Academy. He states that English was perfect until the Great Rebellion corrupted it. Oxford did not take the matter up.

In 1773 we find Beattie arranging to interview George III on the subject of corruption in language. Beattie proposed to edit Addison as a model, to note vulgar words, and to issue an edition of Scotticisms. Among his Scotticisms are *restrict, narrate, notice, I reckon, in place of*.

Landor thinks that a word should be used in one sense only: if *to execute* means *to finish*, he objects to its meaning *to hang* also. He believes that a word's meaning should show its derivation. In our own time very few of us believe in the derivation fallacy; if we do believe in it, we must reject such words as *matinee* (*not* a morning performance), *manufactured* (*not* made by hand). Landor also condemns a phrase like *examine into* on the ground that *ex* means *out* in Latin, or *averse to*, since *a* in Latin is *away from*. To-day good writers ignore the derivation: they write *averse from* and *averse to, different from* and *differ with*.

Modern English.—The lesson we learn from the attempts of writers like Johnson, Swift, and Landor to give language a definite standard is that the history of a language is the history of its corruption. Strictly speaking, there is no corruption; evolution is a better term.

The present age is heretical in many things—morality, religion, politics; it is heretical in language also. It has no respect for words as words; it prefers *wire* to *telegram*, *bus* to *omnibus*, *taxi* to *taxicab*, *bike* to *bicycle*. The most daring, and incidentally the most inartistic, heretics say *under the circs* for *under the circumstances*, and if *under the circs* should become idiomatic English the efforts of every professor and schoolmaster in Britain would not prevail against it.

Let us examine the following quotation from a 1914 short story:

A member once talked about Milton, but the prompt action of the secretary, in pointing out the rule that forbade conversation on modern topics, brought the erring member up sharply.

Member came from Lat. *membrum*, a limb;

talk from O. E. *talian*, to speak; *prompt* from Lat. *promptus*, through French; *action* from Lat. *actum*, to do; *secretary* from Lat. *secretus*; *pointing* from Lat. *punctum*, to prick; *rule* from Lat. *rego*, I rule, which gave Lat. *regulus*; *forbade* from O. E. *forbeodan*=*for*+*beodan*, to bid; *conversation* from Lat. *conversatio*; *modern* from French *moderne*, from Lat. *modus*, treasure; *topics* from French *topique*, from Greek *topikos*; *brought* from O. E. *bringan*, to bring; *erring* from Old French *errer*, from Lat. *erro*, I wander; *sharply* from O. E. *scearp*. Prepositions and conjunctions are usually Old English.

The above passage shows how much of our vocabulary we owe to Latin and French. But it includes only one Greek word, *topics*, and that was borrowed through Latin and then French. And there is not a single word borrowed from modern foreign languages. Yet modern English has taken loan-words from practically every known language.

Modern French Words.—We saw that early French loan-words took on an English habit and pronunciation. At the Restoration (1660) a system of giving French words their French pronunciation grew up, and since then the custom has obtained. English throws back the accent; thus *géntle* from French *gentil* is an early borrowing, but *gentéel* from the same source is late.

The tendency to give the French pronunciation is primarily a snobbish one; the speaker does not want to be accused of ignorance of French. There is no real reason why we should pronounce *trait* "tray," or *envelope* "ongvelope," or *valet* as "valley." In some words the French pronunciation is almost necessary for euphony. *Espionage* is better as "es′pionaj" than "espiónage"; *Chopin* would sound barbarously as "Choppin." And the French soft *g* is sweeter than English hard *g*; "mas-saj′" is probably better than "mássage," "pres-tij′" than "préstige." Yet if these words had been early borrowings we should have had the accent thrown back as in *savage* or *cabbage*. The modern *garage* is not yet fixed; it is pronounced "gar-aj′," and gárage. The latter is becoming popular.

Slang.—Slang words are like the members of the lower middle class of society; they are outsiders who are allowed into the best circles on occasion only. A favoured few are permitted to stay there, and their lowly origin is forgotten in a generation or two. A Cabinet Minister's "salary" is derived from Latin *salarium*, "salt-money," which soldiers received. Originally *salary* was slang, but to-day the word is as respectable a member of society as a Cabinet Minister.

Speaking generally, any word having force and personality will make its way to the front. When Kipling speaks about a steamer "waddling in from the sea he is using a slang word, but *waddling* is the one word for the ship's motion, and anyone who objects to it is merely a pedantic snob. Again, to speak of a drunk man *barging* into a room is to raise a slang word to the level of the best literary language. Words should either suggest a good sound or a fine picture. Anyone who has seen a barge making its way through Thames shipping will appreciate the comparison with a tipsy man.

The chapter on slang in that delightful book *Words and Their Ways in English Speech*, by Greenough and Kittredge, will cure anyone of linguistic snobbery. One finds there that many aristocratic words have plebeian origins.

Modern Word-Making.—The process of change in language never ceases. Every new invention requires a name. We have *telegraph* (Gr. *tele*, far off, and *grapho*, I write), *phonograph* (Gr. *phone*, sound, and *grapho*), and so on. Scientists choose Greek compounds because the Greek language is known to scientists of all countries.

Writers often invent words. Milton invented *gloom*, *moon-struck*, *Satanic*. Newton gave us *centrifugal* and *centripetal* while Huxley invented *agnostic*. Modern prose writers do little in the way of making new words, but the press is always experimenting. In this year 1914, the London papers are using the word "pogrom" as a schoolboy uses a new knife. What the word is supposed to mean is difficult to know It sounds as ill as the ugliest word in London, the word *Goodge* in Goodge Street.

The press is more given to changing the meaning of words than to inventing new ones, and we really need someone to make new terms for old ideas. If the press calls a sordid crime a tragedy, we must use some other word for *Œdipus*; if it speaks about the dramatic statement made by Mr. Asquith when he says "The answer is in the negative," we require a new word for Othello's "I took by the throat the circumcised dog, and smote him—thus." If in the account of a society gathering one lady is described as "charming," another as "beautiful," a third as "sweet," and a thirtieth as "lovely," we really do require a few new epithets for describing lilies, sunsets, and Helen of Troy.

It isn't that language is becoming corrupt; it is merely evolving. If the British public agrees with its society journals in calling the honourable Sylvia de Montmorency Blank "the beautiful daughter of a lovely mother," the British public attaches to the word "beautiful" a meaning that it did not always have. It used to mean "perfect in form"; and the honourable lady would be the last to claim perfection. Clearly we need a new word for "perfect in form." "Perfect" itself would meet the case, but the society papers would quickly welcome it as a fresh adjective.

It is well to attach to a word a definite shade of meaning, but we should beware of snobbery.

Coleridge once heard a lady use some slangy adjective to describe the Falls of the Clyde, and he was annoyed. Of course it is well to say that falls are magnificent, or awful, but if a young lady says they are ripping we should not think ourselves very superior. After all, she means the same as we do. Words like "ripping" are popular because they have no definite meaning attached to them; a revue may be ripping, also the poems of Keats may be ripping. We once heard the latter described as "scrumptious."

Etymology.—This subject is too vast to treat thoroughly in the space permitted by this book, and we can only hint at the delights of the study of words and their history. Any grammar will afford a list of Greek and Latin prefixes and affixes; most of us learned them at school. There is little pleasure in learning that the word "interrupt" is derived from the Latin *inter*, between, and *ruptum*, to break. But consider a word like "rival." This word comes from the Latin *rivus*, a stream. What is the connection between a stream and a rival? Latin had an adjective *rivalis* meaning "pertaining to a stream," and *rivales* was the name given to neighbours who got water from the same stream. We can imagine a breezy encounter between two *rivales* at the river bank, and we can quite easily see how the modern meaning of rival came about.

This instance shows how delightful the science of Etymology can be.

Let us take another example, the word "treacle." At first sight it is difficult to trace any connection between this word and the Greek *thēr*, a wild beast. The Greeks had an adjective *thēriakón* meaning "pertaining to a wild beast." A wild beast bites, hence the word *thēr* became associated with "a remedy for a bite." Greek remedies were often in the form of a syrup, hence *thēr* became associated with a thick syrup, and the original idea of a cure was lost. The same process is seen at work in the history of the word "villain," which is derived from Latin *villa*, a farmhouse. A villain was originally a farm-servant, and in the days of feudalism the labourer was looked upon as a low fellow. Most of Shakespeare's servants are knaves or fools. The word has lost its association with the farm labourer, and a villain is *any* low fellow.

The word "knave" we have just used has a similar history. Its original meaning was "boy.' Servants were often called "boys," and a *knave* acquired the meaning of *servant*. And as the gentry considered servants thieves, the word *knave* came to have its sinister significance.

The student of Etymology must beware of jumping to the obvious conclusion. For instance, the word "belfry" suggests derivation from "bell," but its history shows no connection with "bell." It comes from Middle High German *berovrit*, a place of safety, through Old French *berfroi*. If we go farther back, we find that it is connected with *bergen*, to conceal, and *vride*, protection.

Of less interest are the words derived from the names of people and places. Words like "machiavellian" or "quixotic" explain themselves, but the connection between a sandwich-man and the Earl of Sandwich is not so apparent.

One Earl of Sandwich was a notorious gambler, and to save time he had his food brought to the table in the form of the modern sandwich, hence the name. A sandwich is essentially two pieces of bread with meat or jam or cress between. The man who first likened a sandwichman to a meat sandwich must have been inspired.

The derivation of a word from a place-name is of common occurrence. We have *sherry* from the Spanish town *Xeres*, *china* from *China*, and so on. In our own day we have seen how such words are derived. When Mafeking was relieved, London went into jingoistic hysterics, and now we call any kind of extreme jubilation *mafficking*.

The Bibliography at the end of these articles names the books that the interested student should read. But the science of Etymology should be considered a delicious luxury. It is good to know the history of the words you use, but words change so much that etymology is not a safe guide. It is possible to write good English without a knowledge of the history of words. Nevertheless such a knowledge is well worth having for the reason that the writer feels that he is working with old friends.

GRAMMAR

Books on English grammar lay down the laws of good speaking and writing, and the thinking student is naturally curious to know who made these laws.

The old grammars were the result of classical study; the old grammarians laboured under the false impression that the grammar of Latin was suited to the English language, or they based their grammars on the periodic style of the eighteenth century. They claimed that grammar was a matter of Logic and Reason, but they could not explain, for example, why some classical words formed an English plural, while others took the Latin plural.

The truth is that grammar should not be based on any rules of the past. The only criterion is the usage of the present day; consequently a grammar book is out-of-date by the time it is published. Rules are dangerous; if grammar is to prevent a man from expressing himself spontaneously and easily, then the sooner we drop grammar the better. All progress is realised by the breaking of rules, and since Chaucer's day English has been lawless. Suppose someone had written a Grammar at the time of the authorised translation of the Bible. He might have quoted "What came you out *for to* see?"

or "Our Father, *which* art in Heaven" as examples of correct idiom. No one to-day would think of using *for to* on the plea that a noted grammarian of the seventeenth century had stamped it as a correct phrase.

How, then, are we to know what is grammatical and what is not? There is only one answer worth considering: we must be guided by the practice of the best modern writers. Freedom must be fully allowed. Someone may ask: "Are we then to tolerate that barbarous usage of the split infinitive?" Nearly every teacher condemns it; it is held to be vulgar, corrupt, ugly, what you will. The truth of the matter is that you cannot split an infinitive; our infinitive is itself a corruption. "To" has nothing to do with the infinitive. The split infinitive is slightly specialised and expresses a fine shade of meaning; it is found in the works of nearly all great writers.

What are we to do when there is an option in usage? "Averse to" is used by good writers quite as often as "averse from"; "we had rather" is as good as "we would rather." The only way is to take full use of the option; time will probably eliminate one phrase. The same method may be applied to slang. Many of our words to-day were slang terms once, and by a gradual process they were raised to the level of the literary language. Our *mob* was originally a slang-corruption of *mobile vulgus*; *bounder*, once a slang term, can now be used without quotation marks.

No writer can raise a slang word to the literary level. If a modern writer—for example, H. G. Wells—were to use the verb *biff* for *hit violently*, he could not raise *biff* above slang. But if twenty good writers were to use it, the chances are that others would follow them and raise *biff* as they raised *bounder*. Hence originality in language is like originality in social behaviour—it is liable to be misunderstood. If you wear a cap with a frock coat, and if you are a brilliant talker, you will find that people are staring at—not listening to you. So if you think that good taste requires your writing a sentence like "Socialism is out to knock spots off the blokes that sneak the tin from the poor," you will find that your readers do not think of Socialism because they are shocked by your language.

In politics, in science, in philosophy, the great men are ahead of the rank and file. But in idiom and language there should be no conscious effort to seek originality. After all, language is merely a means, not an end.

Grammar, therefore, will mean to us the usage of the present day. It will guide us in following the conventional language and idiom of the best writers. We shall not concern ourselves with intricacies like parsing, breaking up of elaborate sentences into their subordinate clauses, and other terrors of the Victorian schoolboy.

The subject is so vast that we cannot treat one tenth of it in these pages. Hence we shall assume that the ordinary definition of noun, verb, gender, case, &c., are known to the reader. We shall deal with *bad* English, and try to show why it is bad.

Bad English.—"Bad" English may have been good English at one time; it is bad to-day because it does not conform to the speech of the cultured classes of society. The majority, says Ibsen, is always wrong. In all probability the number of British voters who say "I seen a man" or "I seed a man" is greater than the number of voters who say "I saw a man." It is certain that the majority of voters say "Who did you see?" instead of "Whom did you see?" The standard of usage is the speech of the educated classes. Nevertheless there is always a tendency for speech to sink to the lower level. A bishop will reply to the query "Who's there?" the vernacular "It's me." A learned professor will say to his wife "Who did you see at the Joneses?" But the Bishop when writing his sermon writes "It is I," and the professor in his *History of Rome* writes "Whom did they applaud?"

THE NOUN

Number.—There is no confusion of number when a sentence is perfectly simple. In the sentence "A certain amount of excitement was natural," *amount* is the subject, and *was* the predicate. But in the sentence "A certain amount of excitement and riot were natural," a mistake has been made. The subject is not *excitement and riot*; it was the *amount* that was natural. Hence *were* is wrong in the above sentence.

Collective nouns form a difficulty. Should we say "The audience *was* appreciative," or "The audience *were* appreciative." There we may take advantage of the option; either is right.

Either .. Neither, Or .. Nor.—When a simple conjunction like *and* links two nouns together the two take a plural verb. Thus: "Tom and Willie are foolish." But "Either Tom or Willie are foolish" is wrong; write it out fully as "Either Tom is foolish or Willie is foolish," and you at once see that *are* must not be used. The following verbs are wrong in number:

Neither of the boys were at home (was)
Either he or I are at fault (is)

Most of us know the plurals that are not formed by adding *s* or *es*—*child*, *children*; *sheep*, *sheep*, *trout*, *trout*, *man*, *men*, etc. The only difficulty is one that arises from a confusion of plurals; we have *penny*, *pennies*, *pence*; *brother*, *brothers*, *brethren*. In all cases one plural form has a specialised meaning. I give a boy two *pennies*, but he pays two *pence* for a toy; I catch five *fishes*, but I buy *fish*; I ask my tailor to show me different *cloths*, but I order a suit of *clothes*; I fire *shots*, but I buy *shot*; I lived

with my *brothers*, but when I preach to a congregation I say "Dearly beloved brethren"; I shell *peas*, but I buy *pease*-meal.

The following appear to be plural, but are really singular :—news, riches, alms. We write "My news is scarce," but most of us write "Riches are desired by many."

Smallpox (small pocks) is really plural, yet we say "smallpox is a dangerous disease." "Measles have broken out."

There is no rule for foreign plurals, but the tendency is to Anglicise foreign words. No one speaks of *banditti* or *formulæ* nowadays; we say *bandits*, *formulas*. The foreign plural is retained in *stratum*, *strata*; *analysis*, *analyses*, *tableau*, *tableaux*.

Compound words follow no special habit in forming plurals. We say *commanders-in-chief*, *mothers-in-law*, *lookers-on*, but *pailfuls*, *major-generals*, *sergeant-majors*; sometimes both nouns take the plural form, *e.g.* *men-servants*, *knights-templars*.

Gender.—A thorough knowledge of the gender of nouns is not necessary in English. In Latin gender is all-important, because an adjective qualifying a noun must have the same gender as the noun. We cannot say *bonus mensa* (a good table): we must say *bona mensa*. *Mensa* is feminine, *bonus* is masculine. In English gender has come to denote sex only, although it is usual to refer to a ship as "she" or the sun as "he."

A list of words having unusual genders is of little use. We have one before us as we write. *Spinster*, we notice, is the feminine of *bachelor*, but one never hears the word *spinster* outside of law courts and churches; *bachelor-girl* is now generally accepted. *Drone* is given as the masculine of *bee*; but the bee in a hive is a neuter. If *drone* has a feminine, it is *queen-bee*. *Man-servant* and *maid-servant* have been contracted to *man* and *maid* or *servant*.

Before we leave the subject of gender let us give a topical warning: *suffragette* is not the feminine of *suffragist*.

The Possessive Case.—This case is denoted by the apostrophe *s* ('s). It has often been erroneously supposed that *'s* is a relict of *his*, and our grandfathers wrote on their books "John Smith his book." The *'s* is a relict of the O. E. possessive *es*; the apostrophe denotes the missing *e*.

In ordinary cases the apostrophe is placed before the *s* in the singular, and after the *s* in the plural. Thus we say "The cat's dish" when we refer to one cat, but "The cats' dish" when we refer to more than one cat. In the case of collective nouns we follow the rule for singular nouns. Thus we say "The People's Books," "The children's games."

The apostrophe *s* has lost its old position; we now speak of "Smith the blacksmith's house," "Charles the First's head," or even "Charles I's head," It is usual to write "James's book" or "Guinness's stout." Perhaps the ear is the best guide. "H. G. Wells' novels" sounds better than "H. G. Wells's novels." Euphony makes us write "For conscience' sake," but we write "For Thomas's sake."

When two nouns are connected by *and*, care must be taken. If we write "Smith and Thomson's *History of Greece*," we convey the idea that Mr. Smith and Mr. Thomson collaborated in writing the *History of Greece*. But if we write "Smith's and Thomson's *History of Greece*," we show that Mr. Smith and Mr. Thomson each wrote a *History of Greece*.

Grammars usually object to the use of apostrophe *s* with inanimate objects, *e.g.* "The piano's legs," "The book's appeal." Current usage accepts these possessives, but in good prose "The legs of the piano" is still preferred.

The Pronoun.—A pronoun is a word that stands for a noun. The importance of pronouns is not realised unless one tries to write a sentence without them:

"Tom put on Tom's hat, and, whistling on Tom's dog, left Tom's house."

This sentence shows the danger of ignoring pronouns.

The following sentence shows the danger of using too many pronouns:

"John told James that Charles told him that he was going to Birmingham if he asked him to go." It is impossible to tell whom *he* and *him* refer to.

Personal Pronouns.—The only difficulty about the first personal pronoun is the use of *me*. You knock at a door. Someone within asks "Who's that?" You answer "It's me." Should you answer "It is I"? There is no occasion to say "It is I"; usage has accepted "It's me," and all the pedantic correctness in the world will not oust the phrase.

The second personal pronouns *thou*, *thee*, *ye*, *thine*, *thy*, are obsolete, and should not be used, unless in a novel dealing with a past age.

The third personal pronouns *they* and *their* are often misused in a sentence like the following:

"Each boy and girl will receive their prize when they come forward." The correct sentence is "Each boy and girl will receive his or her prize when he or she comes forward," but even then the sentence is not good. It is better to say "Boys and girls will receive their prizes when they come forward," although there still exists a doubt whether *they* refers to the children or the prizes. "Each boy or girl, on coming forward, will receive a prize" leaves no ambiguity.

Who, which, what.—These are interrogative pronouns when they ask a question: *e.g.* "Who did this?" "Which will you have?" "What did she say?" Confusion between *who* and *whom* often

arises. In conversation most of us say "Who did you see?" Write this: "You did see—who?" and the incorrect grammar is at once evident. "Whom did you see?" is correct.

The Relative Pronoun.—The relative pronoun always "relates" to some noun already used: *e.g.* in "This is the *house that* Jack built" the relative *that* relates or refers back to *house*. *House*, in this case, is called the antecedent of *that* (Lat. *ante*, before; *cedo*, I go). The relative is sometimes omitted when it is the object of a verb: *e.g.* "I appreciate the gift (that) you gave me," "He barks at every tramp (that) he meets."

There is one mannerism in which the antecedent is omitted—"There are who say." The antecedent *people* is understood. This Latinism is better left alone; it sounds pedantic and stilted.

The relative phrase *in which* is sometimes omitted. "The way the Boers acted was annoying" is often written for "The way in which the Boers acted," etc.

In all cases of the relative the elementary principle of subject, predicate, and object must guide. Every schoolmaster knows this type of sentence:—"A farmer who lived in Scotland. He went out to the field," etc. In the sentence "who lived in Scotland" *who* is the subject, *lived* the predicate. Now *farmer* is evidently a subject: where is its predicate? *Went* cannot be the predicate of *farmer*, for it is the predicate of *he*. Cut out the full stop and *He*, and you have good English, for then the relative clause "who lived in Scotland," if cut out, leaves an orderly sentence, "a farmer went out to the field."

A common error is the insertion of *and* before a relative: *e.g.* "He had a cycle with a high gear, and which he pedalled with difficulty." This sentence suggests another error—the separation of the antecedent and the relative. In this case a person who did not know anything about cycles might wonder whether *which* referred to *cycle* or to *gear*. Consider the sentence:—"James Green, the son of George P. Green, who is a well-known pig-dealer, fell from his horse yesterday." Does *who* refer to James or to George? If to James, the sentence should run: "The well-known pig-dealer James Green, who is the son of George" etc.; if to George it should run "James Green, son of the well-known pig-dealer George P. Green," etc.

When there is no ambiguity the relative may be some distance from its antecedent.

Adjectives and Articles.—The indefinite articles *a* and *an* confuse many writers, but if you write as you speak you should have no difficulty. If you pronounce the *h* in "hotel" write "a hotel"; if you drop the *h* write "an hotel." Personally we write "a hotel," "a hospital," "a heroic deed."

Usually *an* is used before a word beginning with a vowel, but here again sound must guide. We write "an uncle," but we write "a unique play."

Repetition of the article often makes confusion. "A poet and critic" may refer to one man, but "a poet and a critic" suggests two men. What can we make of the following? "The secretary and treasurer, along with the chairman, went out to meet the delegate, who is secretary of the Leeds branch, and vice-president."

Was "the secretary and treasurer" one man or two? Was the delegate not only secretary of the Leeds branch, but vice-president also? or were the delegate and the vice-president different men?

If the secretaryship and the treasurership were held by one man, and if the delegate was not only secretary of the Leeds branch, but vice-president also, the sentence should read: "The chairman, along with the secretary, who also holds the position of treasurer, went out to meet the delegate, who is secretary and vice-president of the Leeds branch."

If the secretary and the treasurer are two men, the sentence should run: "The secretary and the treasurer, along with the chairman," etc.

The ordinary adjective presents no difficulty to the young writer. The difficulty appears when the comparative degree of an adjective is used.

Adjectives are "compared" as follows:

Positive	*Comparative*	*Superlative*
quick	quicker	quickest
good	better	best
beautiful	more beautiful	most beautiful

Some adjectives cannot be compared. Queen Anne is dead; we cannot say that Charles I is "deader," because he has been longer dead. If we believe in the derivation of words, we cannot say that one thing is "more unique" than another; *unique* means "being the only one of its kind." But if we accept the modern journalistic meaning of *unique*—"uncommon," we may use the phrase "more unique."

Adverbs are compared like adjectives, thus:

Positive	*Comparative*	*Superlative*
quickly	more quickly	most quickly
well	better	best
beautifully	more beautifully	most beautifully

Now, the young student usually mixes up comparatives of adjectives with those of adverbs.

"John is a quick runner." Here *quick* is an adjective.

"John runs *quickly*." Here *quickly* is an adverb.

We say "John is a quicker runner than Willie," but we cannot say "John runs quicker

than Willie"; we must say "John runs more quickly than Willie."

A good old-fashioned tag to remember is: An adverb tells how, when, or where anything is done.

Any noun can be used as an adjective. We speak of "The *London* Girl," "the *Press* club," "the *farmer* class," etc. But in phrases like "biscuit box," "cab rank" "paper chase," is the first noun being used as an adjective or not?

In writing, the way to obviate any difficulty is to join the two with a hyphen if the first is to remain as a noun. It is better to write *biscuit-box, paper-chase, walking-stick*. In the last named, if *walking* were an adjective, a "walk ing stick" would literally be a stick that walks.

In a sentence like "Labour and religious troubles held the attention of the government," there is ambiguity. It might mean "Labour held the attention of the government, and so did religious troubles."

Labour is a noun used as an adjective qualifying troubles. To prevent ambiguity write the sentence thus: "Religious and labour troubles held," etc.

The Verb.—The most common mistake made by uneducated speakers is the confusion of the verb's tenses. *Tense* means "time"; present tense refers to present time, past tense to past time, and so on.

The past participle is the great stumbling-block. Note the following:

Present Tense	*Past Tense*	*Past Participle*
eat	ate	eaten
grow	grew	grown
see	saw	seen
write	wrote	written

To find the past participle of a verb, add *was* or *have*.

I *eat* a pie (Present)
I *ate* a pie (Past).
The pie was *eaten* (Past Part.).
I have *eaten* the pie.

Similarly:

I *see* him.
I *saw* him.
He was *seen* by me.
I have *seen* him.

Now, when a man says "I seen a dog-fight last night" he is using the past participle *seen* instead of the simple past tense *saw*.

Observe that the past participle is often used as an adjective: *e.g. chosen* ("the chosen people") *forgotten, grown* ("a grown youth"), *risen* ("the risen sun"), *stolen, worn, written* ("the written letter").

Do not conclude that all past participles end in -en or -n. Note the following:

Present Tense	*Past Tense*	*Past Participle.*
swing	swung	swung
sing	sang	sung
hit	hit	hit
sweat	sweat or sweated	sweat or sweated
tell	told	told

Verbs in -ing.—1. *The Present Participle.*—The present participle always ends in *-ing*, and it is always used as an adjective as well as a participle.

"Thinking that his father had come home, James left the house." *Thinking* is a present participle; it is also an adjective qualifying *James*.

Consider the following sentence: "Entering the ballroom, a brilliant spectacle met our eyes." Here *entering* is a present participle; it is also an adjective. What noun or pronoun does it qualify as an adjective? *Ballroom?* No, it wasn't the ballroom that was entering? Spectacle? No; the spectacle was not entering. The sentence is an ungrammatical one. Write it: "Entering the ballroom, Mary beheld a brilliant spectacle," and it is correct. Mary was entering; hence *entering* is an adjective qualifying *Mary*.

2. *The Gerund.*—A verb in *-ing* may either be a participle or a gerund. If it is a participle, it is an adjective; if a gerund, it is a noun. In "Do you object to me *smoking*," *smoking* is a present participle and an adjective qualifying *me*. But in "Do you object to my *smoking?*" *smoking* is a gerund and a noun, qualified by the possessive adjective *my*. Observe closely the following sentence:—

"By constant *drinking*, he became insane" (gerund).

"Drinking constantly, he became insane" (pres. part.).

"She prevented his *going* out" (gerund).

"She prevented him *going* out (pres. part.).

Personally we prefer the gerund in prose style. In our opinion "Sammy believes in Parliament giving Home Rule to Ireland" is not so good as "Sammy believes in Parliament's giving Home Rule to Ireland." "I do not like him associating with bad boys" is not so good as "I do not like his associating" etc. The gerund is nearer the correct meaning in all cases. In "Excuse me smoking," you are asking a lady to excuse *you;* whereas what you really want her to excuse is your *smoking*. Hence "Excuse my smoking" (gerund) is better.

The gerund can be used instead of the infinitive.

"Skating is pleasant" can be written "To skate is pleasant."

The verbal noun, which is really a gerund, is always preceded by the definite article, and followed by the preposition "of": *e.g.* "He set himself to the *mastering* of Latin." (verbal

noun). The gerund proper is seen in "He set himself to mastering Latin."

The Shall and Will Difficulty.—Natives of southern England use *shall* and *will* correctly; the words have for them a certain shade of meaning that the northerner can with difficulty understand. A Scot never gets over the "shall and will" difficulty; he usually adopts *shall* for the first person, *e.g. I shall*, and will for the second and third persons, *e.g.* you *will*, they *will*.

Without entering into the intricacies of the question, we give a general rule that covers most cases.

In the first person use *shall* for the simple future, *e.g.* "I shall call to-night." But if there is any emphasis use *will*, *e.g.* "I *will* do it; you have no right to prevent me."

In the second and third persons use *will* for the simple future, *e.g.* "You will be there at seven?" "He will come." But when emphasis is required use *shall*, *e.g.* "You *shall* be there at seven"; "He *shall* come" (I command him to come).

Should and *would* are used in a similar way. "I should think so," "You would like to go, wouldn't you?" "He would do it if he could." "I would," is used in "I would that she were here."

The "shall and will" difficulty need not trouble the northern writer; if he uses them wrongly, he is in the company of Stevenson, Oscar Wilde, Gladstone, W. B. Yeats, and many other well-known writers (see *The King's English*, pp. 134–156).

The Preposition.—A preposition always governs a noun or pronoun: *e.g.* "*to* the fire," "*in* London," "*through* the village," "the Prince *of* Wales," "*between* two fires."

The preposition *between* should be used when only two things are referred to; we divide an apple *between* John and Tommy, but we divide it *among* John, Tommy, and Bill.

A common mistake is to use the conjunction *unless* instead of the preposition *except*. It is wrong to say "I like everyone *unless* that one"; *except* is the word.

A vexed question is the one dealing with prepositions and their relationship with words that have Latin or Greek prepositions in their composition. *Averse* is from Latin *a*, from, and *versum*, to turn; should we follow the Latin preposition, and write *Averse from?* To do so always is mere pedantry; the derivation really does not matter, and the average speaker does not know any Latin at all. The following are all usual:

"I am averse *to* (or *from*) your going." "He was oblivious *of* his surroundings." "I differ *from* you in appearance, but I differ *with* you on the subject of politics." "Your politics are different *to* mine." "I disagree *with* you (not *from* you)." "The company consists *of* half a dozen members, and its one merit consists *in* its system of quarterly payments." "I am chary *of* doing what you ask."

The older grammar warned its readers against the placing of a preposition at the end of a sentence. They insisted on the changing of "Whom are you waiting for?" into "For whom are you waiting?" Nowadays the sentence may have the preposition at the end; the old joke of the village schoolmaster, "Never use a preposition to end a sentence *with*," was prophetic.

The Conjunction.—*And* is the commonest conjunction. It can be used at the beginning of a sentence (see STYLE, p. 108), and it can be omitted in a list of nouns. Our fathers always wrote "He owns lands, houses, factories and ships." We are beginning to write "He owns lands, houses, factories, ships."

Beware of the phrases *and which*, *and who*. This is wrong: "Mary, the parson's daughter, *and who* is home for the holidays, is to be Queen of the May."

This is right: "The farm which stands near the river, *and which* is the largest farm in the shire, is to be sold"

Certain verbs take special conjunctions after them: I fear *that* (or *lest*), I hope *that*, I doubt *whether* he will come, or I doubt if he will come. "I prefer Mary *than* Lizzie," is wrong; *prefer* takes *to*—*e.g.* "I prefer this *to* that."

SPELLING

Spelling is mainly a matter of eye-training, and it is questionable whether the method of oral repetition obtaining in so many schools is of any value. The only sure way to learn spelling is to read, and we suggest that, if the spelling lesson were abolished in a school, the scholars would spell as correctly as these who "learn" spelling. Four words might be "learned"—*siege* and *seize*, *receive* and *believe*; a rule might be formulated, "after a *c* comes an *e*, after an *l* comes an *i*"; hence *deceive*, *relief*.

Latin roots will guide the student in the spelling of words like *innocent* and *colloquial*. *Innocent* comes from Latin *in*, not, and *nocens*, harmful, hence there are two *n*'s at the beginning. *Colloquial* comes from Latin *con*, together, and *loquor*, I speak. *Conloquial* would not sound well, hence the *con* is changed into *col*. Thus we have two *l*'s at the beginning of *colloquial*.

The other words in the English language we should not "teach."

Spelling Reform.—The great difficulty a child experiences in spelling correctly is that we allow two standards in modern English—a spoken word and the written word. In practice we obey the spoken standard only, but in writing we conform to another standard. Writing stereotypes words; hence the written word is

always lagging behind the spoken word, which is always changing. This stereotyping of words is merely an accidental result of the invention of printing, and our written standard practically stops short at the Middle English stage.

As a result of this dual standard, education is held back. Tell a child that cough is pronounced *coff*, and he will naturally conclude that rough is pronounced *roff*, and plough, *ploff*. Our present system makes a child distrust reasoning, and the whole idea of education is to make children think rationally. Existing spelling hides all knowledge of phonetics.

Language is continually changing. Our modern pronunciation is quite different from the pronunciation of Chaucer or of Shakespeare.

Let us consider the long *a*. This letter is on the way to extinction; you will hardly ever hear long *a* in England, except in the word *father*. It is kept in the Anglican service, *e.g.* in *command*, but long *e* has usurped its functions in most cases. In Scotland the long *a* persists; a Scot orders a bottle of *Bāss*, a Londoner orders a bottle of *Băss*. The difficulty is that we have fifteen vowel sounds, and only five characters to represent them. The only remedy is to combine vowel with vowel, vowel with consonant. This has been done in *ee* and *aw*.

Most consonants remain faithful to their original sounds.

The objector to spelling reform generally bases his argument on association; his defence of the existing order is based on sentiment. "Why change the time-honoured spelling of our forefathers?" he cries. Let us see what "the time-honoured spelling of our forefathers" amounts to. In the sixteenth century *hot* was spelled *hot* and *whot*, the latter spelling being used by Spenser. *Hole* was changed to *whole* in the same century. What would the critic say if *whot* were used to-day by a writer who pleaded that he was following "the time-honoured spelling of our forefathers"?

The plea of association is a poor one; the spelling of classical authors is altered every two generations. It has been said that the spelling of Shakespeare is good enough for the twentieth century; but no one knows what the spelling of Shakespeare was like. For he was not consistent; the spelling in the Folio is not the usual Elizabethan spelling. This suggests that Shakespeare was a reformer of spelling. There was no definite standard in Elizabethan times; Spenser will spell a word in two different ways in the same stanza.

Some defenders of the present system hold that if spelling be changed the idea of a word's derivation will be lost, and thus the tie that binds present and past language will be severed. Suppose the argument were a sound one. The aim of language is the expression of ideas. When a man writes the word *rival* he does not need to know that the word is derived from the Latin *rivus*, a stream. It is no doubt interesting to know that the etymology suggests two neighbours who were always quarrelling about the use of the stream that separated their gardens, but the information has no bearing on the present use of the word *rival*. If, therefore, the argument were sound, it could not be defended.

Now it can easily be proved that the "etymology" defence is a sham. For if the defenders are consistent they will drop the *c* in *scent*; they will spell *fancy*, *phansy*; they will explain why *matinee*, from the French *matin*, morning, means "an afternoon performance," or why manufactured goods are not made by hand (Lat. *manu*, by hand; *factum*, to make).

Some critics say that if we tamper with spelling we obscure meaning, for if *son* is spelled as it is pronounced, *sun*, there will be confusion between *son* and *sun*. But to-day we have thousands of such words. Ask a schoolboy if the word *piece* means part, chessman, bread, coin, painting, play, firearm, music, or opera and he will easily be able to tell by the context what *piece* means.

Spelling reform will come when the general public has lost its superstitious reverence for existing spelling. America will lead the way; the American *favor* is being imitated in business correspondence in Britain, and soon we shall have *honor*, *humor*, *program*, and similar words in our daily newspapers.

All that reformers suggest is that phonetics should guide spelling so that when a word is written its pronunciation is obvious. A revolution cannot take place; all we can hope for is a reform *within* spelling—that is a reform which will reduce existing anomalies by discarding unpronounced letters and letters that mislead one in pronunciation.

PUNCTUATION

The only guide to good punctuation is one's common sense. The purpose of stops is twofolds; they act as signals to mark breathing spaces, and they preserve the correct sense.

Consider the following sentence:

"Cæsar came in; on his head a helmet; on his feet sandals; on his brow a manly frown."

Change the punctuation, and it reads:

"Cæsar came in on his head, a helmet on his feet, sandals on his brow; a manly frown."

It is improbable that any young writer will allow the sense of a passage to be perverted by bad stopping. The difficulty is to know what stops to use.

The stops in general use are the comma (,), the semi-colon (;), the colon (:), the period (.).

The Period.—The period is the strongest of all the stops. It marks a division between one complete sentence and another.

Note the following sentence:—"Margaret walked along the road, the nightingale sang."

Here we have two statements with no definite connection between them. The reader is asked to think about Margaret; then suddenly he is hurried off to the subject of nightingales. Obviously a strong stop must separate the statements; the comma is too weak. This is correct: "Margaret walked along the road. The nightingale sang."

Take another sentence: "He died at the age of fifteen, Death the Reaper does not always wait until the corn is yellow." Here there is a connection between the two statements, but the comma is too weak to join them. A full stop would do, but a semi-colon would meet the case better.

In good writing, a period ends a sentence containing a predicate. Some modern writers ignore the predicate, and in fiction we sometimes find sentences like these :—Day broke. Glorious day. The sun rose. A purple and gold sunrise," etc.

There is no real reason why we should condemn verbless sentences; if they convey a meaning they are justified. But something—it may be tradition and convention, or it may be an innate objection to backboneless things—prevents a writer who believes in style from using such sentences.

A full stop marks the end of a speech, unless "he said" or a similar phrase follows the speech. He said: "Go away"; but "Go away," said he.

It is almost unnecessary to add that the period is the only stop followed by a capital letter.

The full stop is always used after a contraction. We write "George Brown, M.A." The stops after M and A show that M is a contraction of Master, and A of Arts; *cf.* Jones and Co., Esq., James K. J. Smith.

The Comma.—Never use a comma unless the sense of a passage requires one. Read this passage aloud:

"In spite of all their efforts the crew failed to reach the shore. Shivering with cold they clung to the masts and hope left them." A pause is made at *efforts*, at *cold*, at *masts*. Should we place commas after these words? The sense of the passage does not require commas after *efforts* and *cold*, but the average printer would insert them. The case of *masts* is different. At first glance we imagine that the crew were clinging to the masts and to hope. A stop is evidently required. The comma is not strong enough; the semi-colon is scarcely strong enough. The full stop will meet the case, for there is a wide gulf between the two statements. The first tells of the material fact that some men were clinging to the masts; the second is concerned with a spiritual conception.

The passage when punctuated reads:

"In spite of all their efforts, the crew failed to reach the shore. Shivering with cold, they clung to the masts. And hope left them."

There is always a danger of over-stopping. The following sentence is over-stopped. "This, however, the secretary, wisely, refused to allow; indeed, he announced his decision, forcibly, in a full house." This sentence might well be written thus: "This, however, the secretary wisely refused to allow, indeed he announced his decision forcibly in a full house."

The Semi-colon.—As stated above, the semi-colon is stronger than a comma, but weaker than a full stop. It is a stop dear to the stylist; the reader should study the use Stevenson makes of it. The sentence just written affords a typical example of its use. The first part of the sentence refers to the stylist; the second part refers to Stevenson. And, since Stevenson is recognised as a good stylist, there is obviously a connection between the two statements. A full stop after *stylist* would do, but a comma would be too weak.

The semi-colon is useful where the comma might confuse.

"Among those present were the Prime Minister, Mr. Balfour, Mr. Lloyd George, the Chancellor of the Exchequer, the Secretary to the Admiralty, Mr. Churchill." This sentence leaves us with a few doubts. Is Mr Balfour the Prime Minister? Is Mr. Lloyd George Chancellor of the Exchequer or not? Are the Secretary to the Admiralty and Mr. Churchill two different men? If Mr. Asquith is Prime Minister, Mr. Lloyd George Chancellor of the Exchequer, and Mr. Churchill Secretary to the Admiralty, the sentence, to be absolutely clear, requires semicolons.

"Among those present were the Prime Minister; Mr. Balfour; Mr. Lloyd George, the Chancellor of the Exchequer; the Secretary of the Admiralty, Mr. Churchill."

In an ordinary newspaper report clearness would be sought by separating each person by a comma.

"Among those present were the Prime Minister, Mr. Balfour, Mr. Lloyd George the Chancellor of the Exchequer, the Secretary to the Admiralty Mr. Churchill."

The Colon.—The colon in strength lies midway between the full stop and the semi-colon. In the old periodic prose it had a definite value, but in modern prose it is used sparingly. The colon may be used in a proverb where sharp antithesis is required, *e.g.* "Man proposes: God disposes." Some writers use it before a quotation, thus—"He said: 'A stitch in time saves nine,' and sat down."

The colon is often combined with the dash, especially before a list, *e.g.* "The chief towns are :—Leeds, Bradford, Halifax," etc.

The Mark of Interrogation.—Everyone knows that a question must be followed by a question mark (?), but everyone does not know the difference between a direct question and an indirect question.

If I say "Is this your book, Mary?" I am asking a direct question, and the mark of interrogation is necessary. But if I write "John asked Mary if the book belonged to her," I am writing an indirect question, and no mark of interrogation is required.

The Mark of Exclamation.—This is one of the most abused stops we have. We all know the schoolgirl's letter that is full of them. The exclamation should never be used unless something is *exclaimed.* The following are justifiable :—

"Alas!" he exclaimed.
"How I long for the sun!"
"Ah! I understand," he cried.

The chief abuser of this useful stop is the man who uses it to show that he has made a joke. Here is a quotation from *Punch* :—"'This machine,' says an advertisement of a motor cycle, 'Gets You Out of Doors—and Keeps You There.' Frankly, we prefer the sort that Gets You Home Again."

If *Punch* had put an exclamation mark at the end, the mark would have been a notice which read "This is a joke. Laugh, please." Our point is that an exclamation mark, when it means "This is a joke," is an insult to our intelligence. It is a good sign that most of our comic papers have discarded the exclamation mark, although quite a number of them may have ceased to use it because of a natural timidity in using the claim "This is a joke."

The Dash.—The dash usually denotes a sudden break, *e.g.*

"I have come," he said, "to tell you that I—well, why should I force my opinions on you?"

In dialogue the dash is used when one speaker interrupts another.

"I have seen the——"
"I don't care what you have seen," cried the lawyer impatiently.

The dash is also used to denote the omission of letters, especially in what are called unprintable words. In the twentieth century it is the height of stupidity and hypocrisy to write D—n for damn; the word has now no connection with the Latin *damno,* when it is used as an exclamation of annoyance. Literary historians often speak of a work's being damned by the critics, and they simply mean that it is condemned.

Brackets.—Brackets should be used sparingly; they never improve the appearance of a printed page. They are used to denote a parenthesis—that is, a sentence standing apart from the sentence in which it is contained.

"Jones bought a motor car (he always said he would buy one), and when he attempted to drive it, he drove it into the river (he always said he *would* drive it into the river)." This sentence shows that the bracketed clause is thrown in as a kind of comment. Dashes may be used instead of brackets. "Jones bought a motor car—he always said he would buy one—and when," etc.

Quotation Marks.—As the names implies, quotation marks are used when words are quoted. In the sentence "Enough!" he cried, we place inverted commas round the word used by the man who spoke. In the sentence: Mr. Asquith said he could not introduce the bill, no quotation marks are needed, for we are not quoting the actual words Mr. Asquith used. Here is the *direct* speech: Mr. Asquith said "I cannot introduce the bill."

When a quotation comes within a quotation, single inverted commas are used:

Mr. Brown said: "Smith said to me 'You are no gentleman, Brown,' and I threw a brick at him."

Quotation marks are the joy of the literary coward. A man will write: Mr. Brown had just risen to address the meeting when a volley of potatoes came from the rural audience. One "spud" made its mark on Mr. Brown's immaculate shirt-front.

The quotation marks round the word *spud* mean "Forgive me for using this vulgar word; I am trying to explain that these vulgar rustics say *spud* instead of *potato.* The quotation marks show that I am quoting; I should never think of using the word myself."

The man is not only a coward; he is also an intellectual snob. If he has not the pluck to use the word *spud,* he ought not to place the responsibility for it on the shoulders of a long-suffering working-class.

When a word is used with a new meaning, inverted commas are generally placed round it. Newspapers used to write about someone's being sentenced to receive so many strokes with the "cat." The quotation marks meant "We do not mean the common domestic pet, you know. We refer to the instrument of torture." Nowadays, thanks to popular education, there is little chance of the public's mistaking one kind of cat for another, and the press has discarded the quotation marks.

Possibly most people would write "Do you 'rag'?" meaning "Do you dance rag-time?" Here there is some justification for the quotation marks. *Rag* has another meaning, *annoy,* as in the phase "The army ragging case," and confusion might arise. In America, where a student's rag is called a *haze,* the word *rag* might be used without quotation marks for "dance in rag-time."

The Hyphen.—Certain words are usually joined by a hyphen. Thus we always write *walking-stick, Anglo-Saxon, Franco-Prussian,*

rowing-boat, boxing-gloves. Boxing gloves would be gloves that box: a walking stick would be a stick that walks.

It is extremely difficult to lay down definite laws for the hyphen. Obviously a *bookcase* is better than a book-case; but is *Indian-ink* better than *Indian ink?* It is; *Indian ink* is ink made in India, but *Indian-ink* is a special drawing ink that has no connection with India or the Indians. Common sense must be the writer's guide. He will not write *paper weight* because that means a weight made of paper; he will write *paper-weight* or *paperweight.*

The present writer finds it most natural to write *prayer-book, boot-tree, inkbottle, rainproof-coat, window-blind, tobacco-jar, tobacco heart, toothbrush, tooth-powder, gum-arabic, blotting-paper, notepaper, pen-holder, motor-car, a street crossing* (but *street-crossing is dangerous*), *black-and-white drawing* (but a *black and white dress*), *gaslight, daylight, electric light.*

No one can say with authority that the above list is wrong; if a youth says "I prefer *motor car* to *motor-car,*" the present writer says "Good! use *motor car* if you prefer it."

Some writers write sentences like this:—"He owns dwelling- and lodging-houses," but the majority of writers say "dwelling-houses and lodging-houses."

The Apostrophe.—The apostrophe always denotes a letter or letters left out. Thus *can't* has the letters *n o* omitted; *don't* is short for *do not,* and the apostrophe shows that an *o* has been cut out. Only one writer, Mr. Bernard Shaw, has the temerity to reject the apostrophe; in his plays he writes *cant, wont, shouldnt.*

Young writers often ask this question: Shall I use words like *don't* in my writings? To such we answer: It all depends upon what you are writing. If you are writing a letter to a friend use *don'ts* and *won'ts* as often as you like. But if you are writing a formal article or book, you will be wise to avoid contractions. Personally we like them; they help forward a familiarity between the writer and the reader. Most important of all, they help to kill dignity in prose; dignified prose is like a dignified person—remote and austere. If you are a Shaw, or a Chesterton, or a Belloc, you can use contractions with impunity, but if you are sending in essays to English Masters or to University Professors, you will be wise to eschew all contractions.

Naturally much depends on the subject. An article for the *Quarterly Review* will avoid contractions, but an article in *London Opinion* will require them.

STYLE

When we say that a cricketer has a style we mean that he has a cultivated manner of batting. We apply the word "style" to artists, writers, boxers, jumpers, and many others, but we do not say that the coalman has a style of his own in shovelling coals, or that the cook has a style of her own in stirring a pot. Style, therefore, is associated with some art, and it is acquired by patient practice. The style of a Jessop is the result of long practice at the nets; the style of a Paderewski is the result of long practice of scales. But practice alone will not produce style; many cricketers never develop an individual style; many pianists remain mediocre technicians.

Clearly style depends upon the man; he must have a special aptitude—call it talent, genius, what you will—for his art, if practice is to make him a good stylist.

As it is in sport and music so is it in writing. Prose style is an art that can be cultivated. Style in cricket depends upon a natural aptitude for games, but style in writing depends upon something bigger than an aptitude; a man's prose style is the expression of his individuality.

Now a man may have a strong personality and yet lack the means of expressing it. The poet Burns has a good style when he expresses himself in Scots dialect, but his letters, written in English prose, appear to be the efforts of one trying to express his thoughts in a language that is strange to him. Gray speaks about a "mute inglorious Milton"; and no doubt in our villages to-day we have men who are stirred as deeply by a sunset as a Shelley might be, but who, for want of training, cannot express their feelings in words.

There is a tendency to attach too much importance to words. The coster who says to his sweetheart "I siy, 'Arriet, ain't that a stunnin' sunset?" possibly experiences as much elemental delight in beauty as the cultured lady who says "How glorious is this purple and gold!"

The language of prose differs from the language of conversation. Mr. Brown, a suburban gentleman, will remark to his wife "I'm tired of these confounded piano-organs, Mary. That's the fourth that's been here to-day. I'm sick of them, and I'm going to write to the papers about them." But when Mr. Brown sits down to write to the editor of the local paper, he pens a letter something like this:—

"SIR,—I hope that you will pardon my trespassing on your valuable space when I write to protest against the too frequent visits of piano-organs to our neighbourhood. As I write these words, the strains of a music-hall song, played on a piano-organ—the fourth since 10 A.M.—reach my ears, and I think I am justified," etc.

Note that Mr. Brown is not using the language of conversation. Now this letter suggests the individuality of the writer. Mr. Brown is a plain man who does not believe in airs and graces. He tells his story in plain language. He is not anxious about his style; his aim is to stop the visits of itinerant organ-grinders. He is no

great stylist; the hackneyed phrase "trespassing on your valuable space" damns the writing as prose at once.

Mr. Brown has a neighbour, Mr. White, who also writes a letter to the editor. His effort runs thus:

"DEAR Sir,—I beg to associate myself with the spirit of Mr. Brown's letter in last week's issue. It is a distressing circumstance that our secluded corner of the great Metropolis should suffer from a superfluity of raucous sounds which emanate from sundry meretriciously decorated instruments yclept piano-organs," etc.

Evidently, Mr. White is a pompous old gentleman who believes in big words and fancy phrasing. He no doubt speaks of Mr. Brown as "a man who can't write the King's English." Yet Mr. Brown is the better stylist. Mr. White's letter conveys the impression that he is trying to show off his knowledge of big words. His style is stilted, pretentious, foolish. Introducing an obsolete poetic word like "yclept," which means "called," into a letter on piano-organs is like wearing morning-coat, brown boots, and a straw hat.

The young writer is inclined to follow the style of Mr. White. He writes "the Metropolis" instead of "London;" "the Emerald Isle" instead of "Ireland"; "automobile" for "motor-car"; and so on. He thinks that there are common words and special words, just as these are everyday clothes and Sunday clothes. But he does not realise that a fishwife in her working garb is infinitely superior, artistically, to a fishwife in her Sunday best.

Many writers of short stories in our magazines betray their horror of the common word. Where a simple "he said" would be appropriate, they write "he asseverated," "ventured he," "he vouchsafed," or some other stilted expression.

Fear of Common Words.—Daily Journalism has to some extent been responsible for the erroneous idea that the simple word is undesirable. A reporter, when writing up a football match, gives us something like the following:—"After the kick-off, the ball was carried down the field by the Wanderers' forwards. Dickson passed the sphere to Wilson, and the latter, navigating the leather past several opponents, crashed the cowhide far up among the meshes of the enemy's citadel." "Ball," he thinks, is good enough to begin with, but on no account must it be repeated; besides, in his opinion, the report is made picturesque by the words "sphere," "leather," "cowhide."

The frequent repetition of a word gives a sentence monotony, but our reporter forgets there are such things as pronouns. Let us take a simple statement and rewrite it in bad journalese:—

"The King will go to Balmoral next Saturday. It is believed that the Prime Minister will travel north with him and be his guest for a few days. The Queen will remain at Buckingham Palace."

Translated into the language of the second-rate press, this statement reads:

"The King will journey to his Highland home Balmoral, on Saturday. His Majesty will, we believe, be accompanied by the Premier, who will remain in the north for a few days as the guest of Royalty. Our Sovereign will not have the pleasure of his Royal Consort's company on this occasion, as Her Majesty will remain at Buckingham Palace." Fear of repetition seems to obsess all Fleet Street.

Yet repetition of a word will sometimes give a piece of prose emphasis.

"Napoleon might well have been afraid, but Napoleon did not know what fear was," is more forcible, more arresting than "Napoleon might well have been afraid, but he did not know what fear was." Write this sentence in bad journalese: "Napoleon might well have been afraid, but the famous Corsican did not know what fear was"—and you merely make it ambiguous to the young reader. Every reader is not aware of the fact that Napoleon was born in Corsica (*see* REPETITION, *infra*).

We do not contend that big words should never be used, nor do we condemn fine phrasing. The style should be suited to the subject. If I write a note to the gardener telling him to cut the grass on the back-green I do not write

"DEAR MR. JONES,—Please bring your keen blade and see to it that the sward is shorn of its luxuriance."

But if I write a romantic tale of chivalry, I may, with perfect propriety, refer to King Arthur's sword as his blade, and to the grass, where the knight lies mortally wounded, as the sward. Few would suggest that the poetical prose of Francis Thompson, in his monograph on Shelley, is aureate, and therefore bad.

There is a difference between poetical prose and flowery prose. A St. Andrews student—R. L. Mackie—in a description of St. Andrews, the city of his dreams, wrote these words:

"Sometimes I am a grey friar, who has renounced the world, with love and music and all its vanities, till one day a scent of roses is blown into my face, and I find myself weeping."

That is poetical prose, because the thought is a poetical one. Compare it with the following:—

"Lucy in vain sought the dreamy realms of Morpheus, but the dismal wail of feline wanderers kept recalling her to the stern realities of a grim world."

This is merely a flowery way of writing "Lucy could not sleep because of a cat's concert on the tiles."

The thought is commonplace; the cat's concert is a stock joke of the comic papers, and to call it "the dismal wail of feline wanderers"

is ludicrous. The above phrase at first appears to be a humorous exaggeration. Every schoolmaster and every editor knows that such phrases are dear to young writers. Floweriness of diction is often the result of lack of knowledge; the young writer is always ready to pad.

Perhaps we are not far from the truth if we say that most of the faults in prose style arise from poverty of thought and the resulting confusion of mind. One should not write unless one has something important to say. Schoolboys show much confusion of mind in their essays. A boy will write: "George Washington said, 'Father, I cannot tell a lie,' and he was the first president of America." He does not realise that the two statements cannot be connected in one sentence, unless humour is intended. When you read the sentence you think of the legend of the cherry tree and the little hatchet, then suddenly, your mind is carried over many years, and you try to think of a dignified gentleman of fifty-seven. You are invited to leap over a space of time that saw the turmoil of a great civil war, and the leap is too great. If there were any obvious connection between the two statements the sentence might be excused.

If a boy writes:—"Wellington, as a child, spent many hours playing with toy soldiers; and Wellington won the battle of Waterloo," he is not writing great prose. Yet he might contend that the two statements are related, for the whole sentence suggests that Wellington's early pastimes showed his bent for soldiering. But if the boy writes:—"Wellington, as a child, kept white mice; and Wellington won the battle of Waterloo," he will have considerable difficulty in producing a defence of his joining together two ludicrously incongruous assertions.

Confusion of thought is responsible for the type of sentence found under the heading "Correct the following sentences" in examination papers. Everyone knows the familiar "Piano for sale by a gentleman with carved legs." Correction of sentences like this should be done in the nursery, not in the examination room.

Prose Rhythm.—Good prose is always musical. Read aloud this passage from the Authorised Version of the Bible, a book full of great prose:—"How beautiful upon the mountains are the feet of him that bringeth good tidings, that publisheth peace, that bringeth good tidings of good, that publisheth salvation." In these words there are perfect rhythm and harmony.

Consider the following sentence:—

"He came upon the dark red sand, and gazed far out upon the sea." This can be scanned as two lines of verse:

He came | upon | the dark | red sand.

And gazed | far out | upon | the sea.

Any prose that scans like verse is bad; prose should have rhythm, not metre. Ruskin often falls from rhythm to metre. One of his sentences reads:—"And the gathering orange stain upon the edge of yonder western peak, reflects the sunsets of a thousand years." Observe the blank verse lines:

Upon | the edge | of yon | der west | ern peak,

Reflects | the sun | sets of | a thou | sand years.

No one should set out to write musical prose; the music should come of its own accord. Alliteration gives musical effect, but alliteration should never be used consciously. Here is a conscious and incidentally a poor attempt:

"With *h*ounds and *h*orn the *h*unters *m*ade for the *m*arshy *m*oor, whence the *f*rightened *f*ox had *f*led."

Assonance contributes music to prose, but it should come unbidden. Many proverbs rely on assonance for their rhythm, *e.g.* "A stitch in *time* saves *nine*." "Every *little* makes a *mickle*."

Tricks and Mannerisms: *Inversion.*—Words in an unusual order are sometimes used as a trick in style. Modern novelists are writing sentences like this:—"Came a day when I realised," etc. This kind of inversion is not yet accepted as current coin; possibly it will never be accepted, for writing "Came a day" instead of "A day came" appears to be an idle mannerism with no definite merit.

Inversion often has a set purpose. A newspaper report of a social function will run thus: "Among those present were Mr. and Mrs. Brown, Mr. White, Miss Thomson, etc." If the account ran: "Mr. and Mrs. Brown, Mr. White, Miss Thomson, Mrs. Green, etc., were among those present," the reader would have to read a column of names before he discovered the reason of their publication.

Metaphor.—Young writers like to use metaphors. The undergraduate is very proud of himself when he commences an essay on Edward III's Wars, thus:—

"'Mighty events turn on a straw,' says Carlyle, 'the crossing of a brook decides the conquest of the world.' Can we apply Carlyle's dictum to the Wars of Edward III? We cannot. We cannot glean any straw from the field of circumstance; we cannot point to any river in Edward III's path and say "This is the Rubicon.'" This is no exaggeration of stilted rhetoric; the present writer wrote these very words when an undergraduate.

Metaphors are dangerous to handle, especially when used by inexperienced writers. It is easy to speak of a statesman as a pilot steering the ship of State through a troubled sea, or of a clergyman as a shepherd leading his flock; but these are hackneyed metaphors.

The young writer should not strive to make elaborate metaphors; if he does, he will surely fall. Many a student has invented metaphors that raise laughter. Examples of mixed metaphors are :—

"He sowed his wild oats, but they came home to roost"; "To take arms against a sea of troubles" (Shakespeare); "I refuse to be saddled with a sinking ship."

An essayist recently wrote this sentence :—"The idle rich are parasites preying on the carcase of a dead civilisation." Now, to call the idle rich parasites is good, but to speak of parasites as *preying* is not so good. We speak of an eagle's prey or a tiger's prey, but we do not as a rule speak of insects' prey. Again, a carcase is a dead body, hence the adjective *dead* before *civilisation* is superfluous. Moreover, our modern civilisation is not dead; it is merely asleep. If the essayist felt that he *had* to use a metaphor he might have written: "The idle rich are the drones of the hive; they eat the honey that the workers have gathered and give no labour in return." Both *parasites* and *drones* are common expressions for "the idle rich," but they are too apposite to merit the epithet "hackneyed."

Repetition.—Repetition may be used for clearness, but as a rule it is an orator's trick for procuring emphasis. We have all heard this sort of speech: "The Liberal Party, gentlemen, stands for liberty; the Liberal Party stands for equality; the Liberal Party stands for fraternity." In writing, repetition like this should be avoided. Pronouns usually do away with the necessity to repeat, but pronouns do not always avail. In the sentence: "Thomson asked Jones about Smith. He said he was going to Brighton for a month," there is a want of clearness. Does the first *He* refer to Thomson, Jones, or Smith? Write the sentence: "Thomson asked Jones about Smith. Jones said that Smith was going to Brighton for a month," and you have clearness.

Repetition for emphasis is a common device in prose style. A simple statement, "The nation made him a hero and then a god," is more emphatic if written "The nation made him a hero, and then it made him a god."

Balance.—Let us study the following sentence: "Among those present were M. Paderewski, the celebrated pianist, Mr. George Bernard Shaw, the brilliant wit and dramatist, Mr. David Devant, the great illusionist, and Mr. John Smith." Evidently Mr. Smith is not famous at all, or is so well known that description is needless. Whatever the reason for omitting any distinguishing characteristic of Mr. Smith may be, the whole sentence is inartistic. Something is lacking; if it had ended "and Mr. John Smith the local butcher" the rhythm of the whole sentence had been complete, although the matter of the sentence had been puzzling.

Take another instance: "In the Middle Ages men believed in kingship with all its pomp and pageantry; in modern times men believe in democracy." There is a lack of balance here; we have added a descriptive phrase to *kingship*, but not to *democracy*. And the force of the sentence lies in the antithesis of *kingship* and *democracy*. Rewrite thus:—"In the Middle Ages men believed in kingship with all its pomp and pageantry; in modern times men believe in democracy with all its sham and shoddy," and the two halves are balanced.

Mechanics of Style.—A sentence beginning with "And" will often lend grace to style, especially when "and" is equivalent to "Moreover," *e.g.* "The Elizabethan playwrights gave to the drama an extravagance it had never known before. And extravagance was the one thing the drama required."

A series of "ands" gives a sweet simplicity to a romantic narrative. This might be the conclusion of a romantic tale :—

"And hand in hand the lovers wandered by the quiet stream. Joy was in their hearts, and laughter on their lips. And for them time stood still. Love had come to them, and Love recks not of time. Love is for all eternity."

The repetition of "and" lends a quietness to prose of this kind. The student should read in Malory's *Morte d'Arthur* or in Maundeville's book of travels. These writers use "and" as a child uses it in telling a story; and the result is a delightful simplicity and charm. One modern writer, Mary Johnson, the writer of tales of Virginia, is an artist in the use of "and." Read *By Order of the Company*, and you will find that much of its charm depends on the archaic arrangement of sentences.

Study the writings of authors like Stevenson and Shelley if you want to discover great style. The former almost always uses the correct word; the latter in his letters shows what rhythmical prose should be.

The prefaces of Bernard Shaw are good as a specimen of modern prose. Compare his style with that of any noted writer of the nineteenth century, and you will find that style is a mere incident with him. He has no airs and graces; he has something to say, and he says it forcibly and well. In his case the style is the man; his prose betrays his personality.

HISTORY OF ENGLISH POETRY

Early English Period.—The Anglo-Saxon invaders of Britain were of various races. It is known that Jutes were among the number, and philologists think that Frisians came over also. These invaders brought with them the stories extant in West Teutonic civilisation. Their stories were not written: they were handed on orally, and they were sung by minstrels or

scops. There must have been hundreds of these poems, but only a few are preserved.

Widsith, the first English poem, is an account of a minstrel's wanderings. But the most valuable Old English poem is *Beowulf*, an epic. This poem tells of the exploits of a hero Beowulf. and the scene is laid probably in Denmark. It is clearly the product of a civilisation that liked hard fighting and bloodshed. Beowulf does some marvellous feats, and he tells delightfully tall stories about his previous deeds of prowess. Read the poem—good translations are numerous—and you will learn much about the customs of our forefathers. The tale is well told: you actually see the mead-benches and the hard-drinking warriors; you see the monster Grendel stalking through the banqueting hall; you hear the clash of arms. There is no personal note, no lyric in *Beowulf*. The early Saxons were not introspective; they liked a rattling tale of doughty deeds.

The only approach to lyric, that is expression of passionate personal feeling, in Old English is the *Complaint of Deor*. Deor is a minstrel whose rival has been preferred before him, and his "Complaint" is evidently heart-felt.

These three poems are *pre-conquest* poems; they were known to the Anglo-Saxons before they invaded Britain.

A glance at an Old English (O. E.) poem will show that it differs greatly from a modern poem. The O. E. language is unreadable to anyone save a specialist. It is not commonplace or prosaic; in *Beowulf* we find the sea called the "'whale's path," the "swan's road," the "seal's bath," etc. And the arrangement of the language is quite different from the arrangement of modern poetry. There is no rhyme, nor are the verse lines of any definite length. The chief characteristic of O. E. verse is its alliteration; generally two words in the first half of the line, and one in the second half begin with the same consonant, and these alliterated syllables are emphasized in reading the poetry. There is no idea of compression. The poets practised extended narrative, long-winded parallel phrases, circumlocution and repetition. Many phrases are part of the stock-in-trade of the minstrel, and are used without meaning. In *Beowulf*, for instance, Hrothgar knows where Grendel's den is, yet he says "I know not whither she has gone." Emphasis is gained by repetition; in *Beowulf*, line 1431, we have "they heard the sound of a horn. The horn sounded." Sometimes the same idea is repeated in different words four or five times. All these stock phrases are known as *Kennings*, and as a rule they are mere padding.

Beowulf gives us much information about the minstrel. Possibly in the earliest times there was no profession of minstrels. Kings often were minstrels; King Hrothgar takes the harp twice; later we find King Alfred disguising himself as a minstrel and entering the Danish camp; in Norse Sagas kings often act as minstrels.

The main duty of the minstrel was to transmit news; *Beowulf* hears of Grendel in song. He had also to celebrate any deed of valour done by his chief, and we generally find him flattering his lord. He was always of noble descent, but towards the end of the O. E. period he degenerated. The minstrel of the Middle Ages was the descendant of the Roman actors, and was a kind of acrobat or a pantomimist.

Widsith, *Deor*, and *Beowulf* are heathen in origin, but most O. E. poetry is Christian in subject. To appreciate the O. E. religious poems we must understand what Christianity meant to the Anglo-Saxons. The Teutonic warrior did not understand theology; what appealed to him was the pomp and circumstance of Christianity. The Roman bishop had an imposing retinue; he càme to Britain under Imperial authority. For centuries paganism and Christianity existed side by side; the warrior took the simple plan of adding God to his other deities. The Twelve Apostles were described as "Nobles round a ring-giver"; later, in Middle English romances, the Twelve are gallants. The Devil was the greatest warrior of all. The Anglo-Saxons borrowed the language of Christianity, but the meaning to them remained pagan. For example, "Providence" was used with the O. E. meaning *wyrd*, "relentless fate."

The names associated with the post-conquest religious poems are those of Caedmon and Cynewulf, but nothing definite is known about the authorship of the poems. There are many lives of saints, full of miraculous happenings. *Juliana*, of which there are translations, is a typical "Life"; it shows how credulous and elemental the early Teutonic Christians were.

To this time belong a few secular poems—the *Wanderer*, the *Ruin*, the *Seafarer*. These three poems are full of fine description.

The invasion of the Northmen practically killed O. E. poetry. After Alfred the Great's time we have very few poems. The best known are the *Song of Brunanburgh* (937), which tells of Athelstan's victory over the Northmen, and the *Battle of Maldon*.

Norman Conquest to Chaucer (1066–1400).—In the English language section we have seen how the coming of the Normans influenced our language. Many people vaguely imagine that the Normans brought French poetry with them. There was little or no French poetry to bring. Long before 1066 the O. E. verse was breaking down, and the new poetry was taking its place. The Latin hymns of the Church were familiarising people's ears with definite metre and rhyme. French had followed the Latin style, and when Provençal lyric arose it greatly influenced the prosody of English poetry.

Between 1066 and 1200 we have no poetry at

all, but soon after 1200 we have Layamon's famous poem, the *Brut* or British History, in reality a romance. This poem is of the highest importance prosodically, for it shows clearly the transition from O. E. prosody to metre and rhyme. The poet often forgets his O. E. alliteration and its accents, and uses rhyme. The *Ormulum*, the *Proverbs of Alfred*, the *Proverbs of Hendyng*, *The Fowl and the Nightingale*, *Genesis and Exodus* all show the transition between the O. E. verse and the modern metre.

The O. E. alliterative verse did not die without a struggle. The *Pearl*, *Patience*, *Cleanness*, *Gawain and the Green Knight*, and lastly Langland's *Piers Plowman* all belong to the alliterative camp.

Before Chaucer's time there was a period of romance writing, but nearly every romance was a translation or adaptation from the French. When the Roman theatres were destroyed, the *mimus* became a travelling "turn." From the eleventh to the fourteenth century the *mimi* were welcomed everywhere, although most of them were poor and thriftless. In late fourteenth century they formed guilds, and the Church patronised them.

The Romance.—Medieval Romance arose in France. Verse romance dealt with all subjects—classical subjects, folk-lore, etc.—and each romance was invented by various authors. The chief subjects were love and chivalry, and they usually ran in cycles. Thus we have the Round Table or Arthurian Cycle and the Charlemagne Cycle. Now these romances differ fundamentally from the *Beowulf* type of epic. There is no love in *Beowulf*; the hero's strength does not come from love for a cause, but from brute force, elemental thirst for slaughter. *Beowulf* does not fight for God or for woman. Yet in the O. E. epic, although we find stiff court etiquette, the poor are not despised.

In the romance proper we at once meet with chivalry and its concomitant snobbery. The hero is inspired by a lady-love, and, like a true aristocrat, he believes in the importance of social status.

The *chansons de geste* and the *Song of Roland* mark a transition stage between the *Beowulf* and the *Arthurian Cycle*. In *Roland* woman plays a small part, and courtesy is not mentioned. The *chansons* differ from *Beowulf* in that their warriors do not fight for fighting's sake; Christianity is fought for, and faith gives the warrior superiority. It is curious that a "hero" in those days had no definite nationality. Roland's story was handled in Germany and Italy, and a group of Norse sagas grew up round the story.

Whenever we come to Arthurian romance we are in romance proper. Pageantry, sumptuousness, and colour are dwelt upon. In *Beowulf* the emphasis was on war, in the *chansons de geste* on war for a cause; in the Arthurian Cycle all the emphasis is on love. *Beowulf* and *Roland* were both founded on history; Arthur's story was founded on a general legend of a hero. This late romance was idealistic; Arthur's knights all represent Virtue.

We may appreciate Chaucer if we do not know romances like *Havelok the Dane*, *King Horn*, *Guy of Warwick*, *Bevis of Hampton*, but we cannot understand him unless we realise the great importance of the *Roman de la Rose* and its influence on English poetry. The *Roman de la Rose* is an allegory which coloured English poetry for about three hundred years. It is the work of two French poets. The first part, by Guillaume de Lorris (*d.* 1260) is a poem of love and chivalry. It tells of a dream—a garden on a May morning, a company of fair folk, a carol, and is full of gorgeous colour. The second part, by Jean de Meung (*d.* 1320), is in violent contrast to the romantic Lorris's work. It is full of satire on politics and morals. We shall see that most English poets followed the "dream" tradition, but we shall find bold spirits who followed Jean de Meung's realistic method.

Lyrics.—As the Romance followed French models so did the English Lyric follow the troubadours of Provence and the trouvères of Northern France. It is significant that some of our earlier lyrics show the English and the French versions side by side. Perhaps the earliest English lyric is the *Cuckoo Song* beginning "Sumer is icumen in." The musical importance of the canon in form is a striking parallel. See MUSIC (pp. 383–414). At the same time another kind of lyric throve—the lyric of satire. Lawrence Minot, a poet with a marvellous command of verse forms, shows this kind of lyric at its best. The importance of Minot is that he explains Chaucer; he shows what kinds of verse Chaucer had before him.

Chaucer (1340–1400).—The poetry we have been discussing was for the most part second-rate work. It was struggling to find good metres, and the changing of language forms resulted in poets not knowing where they were. English poetry needed a poet who would reduce its warring elements to harmony, and it found that poet in Chaucer. He used many different stanzas, the heroic couplet and other measures, and in each his words flow smoothly and perfectly.

Although printing was unknown in his time, Chaucer knew much of the literature before him. He makes fun of the more foolish romances in his *Rime of Sir Thopas*; he refers to alliterative poems as *rum ram ruf*.

In subject matter and style he began by following the *Romance of the Rose* tradition, and it should be noted that the *Rose* was a hundred years old when Chaucer translated it.

Chaucer's work is sometimes divided into three periods: I. Period of French Influence;

II. Period of Italian Influence; III. Period when he becomes wholly English. The division is only roughly true. He visited Italy often, and was much influenced by the works of Petrarch and Boccaccio. Probably Boccaccio's narratives led Chaucer to break away from the *Rose* tradition. At any rate he did break with the *Rose* tradition. His *Book of the Duchess, Parliament of Fowls, House of Fame* all follow the manner of Guillaume de Lorris; all have the artificial "dream" allegory. But in *Troilus and Cressida* Chaucer has caught the manner of Jean de Meung; he ceases to idealise woman, and represents her as fickle, sensuous, and dangerous. Queen Anne of Bohemia remonstrated with him about his realistic treatment of woman, and Chaucer wrote, as penance, *The Legend of Good Women*, a poem in the old de Lorris manner. *Troilus* belongs to his Italian Period, the *Legend* was written just before the *Canterbury Tales*. We may conclude therefore that Chaucer never got away from French influence.

His greatest work is the *Canterbury Tales*. A band of pilgrims sets out for Canterbury, and on the way each one tells a tale. Possibly Chaucer got the idea from Boccaccio's *Decameron*. The great importance of the *Canterbury Tales* lies in the fact that they form an excellent gallery of portraits. Previous poetry practically ignored "drawing from life"; poets wrote paraphrases of Scripture like *Genesis and Exodus*, romances like *King Horn*, allegories of the *Rose* variety, but all these were divorced from real life. You read a medieval romance, and the hero does not *live;* but in the *Canterbury Tales* each character is real, you feel that you could talk to the Miller or the Monk.

Chaucer had no definite message. He did not set out to preach a gospel; all he cared for was the *Art* of story-telling, the *Art* of poetry.

For many years English and especially Scottish poets copied Chaucer, but there are two poets of the period who cannot be classed as Chaucerians; these were Langland and Gower.

Langland.—*The Vision of Piers Plowman* is, as we noted above, a continuance of the O. E. alliterative poetry. It is a long confused allegory, and its importance lies not so much in its poetry, for Langland was no great poet, as in its matter. Langland was a reformer. Chaucer satirised society in a genial way, but in the main he thought society good. Langland satirised society because he saw its rottenness. He thinks that the evils of society will be redeemed if squire and vassal, clerk and layman understand their proper duty. He is no socialist; the existing form of government is good enough for him if its abuses are abolished.

Gower.—Chaucer was a man of genius: Gower was a man of talent. He began by writing French, then Latin, and finally English verse. He stuck to his French models, and used the octosyllabic line with the French lack of freedom, thus gaining the title of "Correct" poet. His *Confessio Amantis* begins in the *Rose* manner, and rambles into various classical and medieval tales. But the book lacks enthusiasm and humour; even its love scene leaves one cold.

From Chaucer to Spenser: *The English Chaucerians.*—The poets who followed Chaucer and avowed themselves imitators of the "Master" were at best mediocre poets, at worst atrocious versifiers. The poets from Lydgate to Hawes seem to lack a sense of music and rhythm. Lydgate, Occleve, and Hawes are the worst offenders. The most interesting of the lot is Skelton, who wrote frank "doggerel." He tried all forms of verse, but, without genius, could not keep his "free" verse from clumsiness.

Early Scottish Poetry and the Scottish Chaucerians.—Scottish poetry was late in being born. The only poetry that could have arisen would have sprung from the Lowlands, where a Northern English dialect was spoken, but the fury of the Danish invasion prevented any poetic outburst. Then in the stress of the War of Scottish Independence literature had no chance to flourish. The first Scottish poem is Barbour's *Brus*, a rhyming chronicle rather than a poem. Blind Harry's long poem *Sir William Wallace* is a kind of *chanson de geste*, full of improbable incidents. Barbour shows no hatred to England in his patriotism; Blind Harry's patriotism is coloured by hot hate of the Southerner.

In the Golden Age of Scottish poetry patriotism is seldom seen in poems. Henryson, Dunbar, Douglas, and other Scottish Chaucerians, set out to follow the *Rose* tradition in subject, and Chaucer, Lydgate, and Gower in manner. It is a strange circumstance that they admired Lydgate and Gower equally with Chaucer.

It should be remembered that Middle Scots was an artificial, literary language which was never spoken, and that the Scottish poets always called their language "Inglis." Dunbar sneers at the poet Kennedy for using Gaelic or "Erse."

Roughly, the difference between the English and the Scottish Chaucerians is that the former follow the de Lorris—*i.e.* the chivalrous, idealistic part of the *Rose*—while the latter write in the satiric style of Jean de Meung's part of the *Rose*.

James I.—It is doubtful if the *King's Quair* was written by James I of Scotland, but modern criticism is inclined to consider his claim valid. It is an allegory of the *Rose* variety, with its dream and garden and its fair lady. The poem has much of Chaucer's cheerfulness, and not a little of Gower's didactic moralising.

Henryson.—Henryson (*b.* 1425) is the best of Chaucer's disciples. Like James I, he uses the allegory, but his poems show a desire for something freer. In the *Garment of Good Ladies* he

uses allegory combined with ballad form, and is evidently more concerned with art than moralising. In the *Bluidy Sark*, in ballad stanzas, he drops allegory altogether. His best known work is the *Testament of Cresseide*, which undertakes to complete Chaucer's *Troilus*. Henryson makes Cresseide a leper; Troilus passes and gives her alms, neither recognising the other. When she discovers his identity she dies. Here we have a grim realism greater than Chaucer's; a stern sense of justice and of doom not found in Chaucer.

The *Fables* are Henryson's best work. In them he tells in his own way some of Æsop's fables. To each he adds a *moralitas*, for he could hardly get away from the idea that art should teach as well as delight. Of great importance are his descriptive touches. Chaucer's described *man:* he was not a nature poet. The *Rose* followers described conventional, artificial landscapes and animals. Henryson breaks away from this: he describes scenes and animals known to him.

Robyn and Makyne, a pastoral, is great. A pastoral to Vergil and Petrarch was a poem in which shepherds and shepherdesses were used to satirise town life, the clergy, etc., and in Milton's *Lycidas* we find the ancient idea of satire and invective. Henryson breaks away from this tradition, and writes a real pastoral.

Dunbar.—Some people contend that Dunbar (*b.* 1460) is the greatest Scottish poet. Like the others, he is affected by the *Rose* tradition; his *Golden Targe* and the *Thistle and the Rose* have the "May morning" business, but, in both, Dunbar uses the allegory as a background for painting on. In short, he drops spiritual allegory for art.

As a grim humorist he is great. *The Twa Maryit Wemen and the Wedo* is coarse; it has not the subtle humour nor the acuteness of perception of Chaucer, but it has passion and breadth.

The Ballad of Kind Kyttok, the tale of an old wife's amusing adventures at Heaven's gate, gives us a good idea of Dunbar's "modernism"; it has a demonic humour found only in Dunbar, Burns, and Byron (in his *Vision of Judgment*).

Dunbar is a master of verse forms; he uses "aureate," *i.e.* coloured diction, and develops a rich pictorial style. He is a great satirist, but he never writes to reform abuses. In short, he is an artist, not a moralist.

Douglas.—The last of the four great Scottish poets is Douglas (*b.* 1474), best known for his *Æneid*. He wrote the *Palice of Honour*, a *Rose* allegory, but he innovated by mixing classical mythology with religion. *King Hart* is a moral allegory of the *Piers Plowman* type. His best work is his *Prologues* in his translation of Vergil. In the main he is of the old school; he looks back to Chaucer rather than forward to Spenser, and the Renaissance.

Lindsay.—The poet Lindsay was born in 1490. He was a reformer, the poor man's friend; he hated hypocrisy and satirised it fiercely. His allegory is a thin cloak that hides satire on medievalism. His poetry is founded on the misgovernance of Scotland. His greatest work is *The Satire of the Three Estates*. His art is uncouth; he is a politician and preacher rather than a poet.

Nature in Scottish Poetry.—We have seen a gradual breaking away from the sentimental idealism of the *Rose* allegory. In allegory nature was purely conventional; the sun always shone; there were no clouds. The *King's Quair* is nearly all sun and convention. Henryson in his *Fables* gives a vivid picture of autumn and winter and cloud—the first example of realism. Douglas in his seventh prologue paints a nature-picture of dread and awe. In the main the Scottish poets make for realism in nature studies; they paint nature as it is, not as they want it to be.

English Ballads, Carols, and Lyrics.—A ballad is usually a tale told in verse, *e.g.* Henryson's *Bluidy Sark*. All ballads are probably broken down epics and romances; many of them are for certain. And they are seldom earlier than the fifteenth century. Scottish ballads are better than English ones. The reason for this is that in England printing was established, and the ballads were stereotyped. In Scotland they were collected late, after long years of polish in being handed down orally. They dealt with all stories—romances, love stories, local tragedies, etc.

These ballads familiarised the people with ballad measure, and at the time when Lydgate and Occleve were stumbling in bad verse, people must have known the rattling rhythm of good ballads.

In the fifteenth century too carols were popular. Ballads were recited; carols were sung to music. The ballad had many subjects and few metres, but the carol, limited to a religious subject, sought variety in form.

In the Mystery Plays, Moralities, and Interludes (*see* DRAMA, p. 134) snatches of lyric appeared, and as drama was popular, the lyrics of these plays must have assisted ballads and carols to rescue poetry from the hopeless verse of the Chaucerians.

Italian Influence.—Wyatt and Surrey are usually coupled together as the poets who introduced Italian influence. But the credit belongs to Wyatt. He introduced from Italy the sonnet and various lyric measures. He tried hard to perfect the loose verse left as legacy by the Chaucerians, but his success was not complete. Surrey completed his work. Wyatt would pronounce "suffer" as "suffér" if rhyme required it, thereby following Chaucer; Surrey

insisted on each word's having its proper standard. His verse is a great advance on Wyatt's. Moreover, he is famous as the introducer of blank verse.

Wyatt and Surrey gave English verse strictness, and this strictness obtained until Spenser's time. Gascoigne used blank verse in the *Steel Glass*, but his chief title to notice is his being the author of *Instructions*, a book telling poets to "keep the measure" in writing verse.

Sackville shows the result of Wyatt and Surrey's teaching; in his poetry is the new music and freedom of the Renaissance. And Sir Philip Sidney in his *Stella* sonnets is far beyond the rude attempts of the reformers.

Spenser.—As Chaucer perfected the mediocre verse of his predecessors, so Spenser took up the verse of the reformers, Wyatt, Surrey, Sackville, and perfected it. In the *Shepherd's Calendar* you find him experimenting with diction and metre. He uses archaic and dialect words, hence we find Ben Jonson saying that Spenser "in imitating the ancients writ no language." In his masterpiece the *Faërie Queene* he shows the results of his experiments—perfect music and diction. Many of the passages are full of purple and gold.

In subject the *Faërie Queene* is an allegory—to many readers, it must be admitted, a tiresome allegory. It is full of knights-errant and villains, chaste women and bad women. And like a true romance it shows that good always triumphs; Spenser is no realist. He idealises Queen Elizabeth, possibly the least ideal women in history. He had no definite message as Langland had: allegory was to him a mere framework for his glorious word-pictures. In Spenser's work subject is of no account; the treatment is everything. Hence his greatness lies in his pictures and music. He is the forerunner of poets like Keats who love beauty for its own sake, rather than of poets like Blake and Shelley who have beauty and a vision.

From Spenser to Milton.—The poets immediately following Spenser are usually called the Spenserians, but the appellation is misleading, for two other poets influenced the poetry of the seventeenth century. They were Donne and Ben Jonson.

Donne.—Most writers call Donne the head of the "Metaphysical School of Poetry." "Metaphysical" here means "beyond the physical." Hence Metaphysical poetry strove to give words and phrases a meaning beyond their obvious meaning. Donne's own poetry is full of passion and fine music, but his imitators carried the Metaphysical poetry to ludicrous extremes.

Donne is a good example of the intellectual Renaissance wit, as shown by his mathematical analogies and classical phraseology. Spenser shows Gothic art; his is beautiful. Donne on the other hand is clever; he looks on verse as a task, but he performs his task excellently. The reader should turn to the articles on ART for a full discussion of the Renaissance, and all that it meant.

Ben Jonson.—Jonson is usually spoken of as a classical poet, "classical" referring to Greek and Latin. The main characteristic of Greek literature is its moderation; it has no excess, no ornament for ornament's sake. Romantic literature is very different; think of the French romances with their jumble of incident, their lack of unity. Spenser's *Faërie Queene* is unclassical; it has all the exuberance of romance. So when we call Ben a classical poet we mean that he eschewed excess of ornament. He copied the balance and "correctness" of the classics, and hated extravagance. His well-known song "Drink to me only" has nothing far-fetched about it; it is simple.

The Influence of the Great Three.—We may say with some truth that Spenser followed Italian, Ben followed the classics, and Donne followed neither. The Fletchers—Giles and Phineas, Browne and Wither show the influence of all three. Carew, Suckling, Lovelace, and Herrick are disciples of Ben. They retained his classical form but they introduced sentimentalism and "conceits" (*i.e.* extravagant fancies) of the Metaphysical school of Donne.

Compare Suckling's "I prithee send me back my heart" with Ben's "Drink to me only," and you will find Suckling's poem rather trite and "conceited." But Herrick beats Ben in grace and compression.

Donne's followers included Herbert, Vaughan, and Crashaw, but these poets also owe something to Spenser's music and Ben's simplicity. The Metaphysical school was in the main bad. When Crashaw writes of a lady's eyes as "walking baths, compendious oceans," poetry is evidently in a bad way.

Euphuism.—In Elizabethan times there was a great vogue of extravagant language and thought. Other countries suffered from the same trouble. In Italy Marini popularised extravagant writing. Euphuism in England was the equivalent of Marinism in Italy. The name arose from John Lyly's *Euphues*, a novel full of excessive alliteration, far-fetched "conceits," and extraordinary similes. Euphuism became fashionable, and, as we shall see under DRAMA, Shakespeare and others came under its influence. Euphuism in prose and the Metaphysical in poetry are the main features of the period.

Shakespeare.—It seems foolish to place Shakespeare after Herrick in a discussion of poetry. Our reason for doing so is that Shakespeare stands apart from any school.

Shakespeare the dramatist we discuss elsewhere; here we are concerned with the poet. No one denies that he is of the highest rank poet. The blank verse of his plays is magni-

ficent; his lyrics and sonnets are unsurpassable in their music and painting; his poetical imagination, at least in his later works, is unlimited. Under DRAMA we discuss Shakespeare's philosophy and message (p. 136). His importance in the history of poesy lies in the fact that he perfected the form of poetry, having for one thing absolute confidence in his language. He has more freedom than Spenser. He follows no rules as Gascoigne did; his guide is his ear. Hence we find his lyrics tripping along in all kinds of measures, his blank verse ignoring all conventional pauses and running on in paragraphs. Before him Marlowe, Peele, Greene, and other dramatists used blank verse; but, on the whole, without freedom. They were apt to stop at the end of each line, to bring the pause (cæsura) in at a fixed point in the line, to use ordinary feet like the iamb and the trochee and to ignore feet of three syllables (trisyllabic feet). Shakespeare when he began was conventional too, but he soon sought freedom in his blank verse.

The Decline of Blank Verse.—In his late plays, *e.g. The Tempest,* Shakespeare's blank verse becomes too free; it uses much redundance, *i.e.* an extra syllable at the end of each line. Beaumont and Fletcher show the same fault, only more so. The later poets Davenant and Suckling exaggerate this freedom until their blank becomes a kind of prose.

Elizabethan Lyric.—In the late years of the sixteenth century a great lyric outburst occurred. At this time many wrote verse for private circulation, and these verses sometimes found their way into miscellanies. An early Miscellany is the *Paradise of Dainty Devices* (1576), but in it is very little lyric. The *Gorgeous Gallery of Gallant Inventions* contains much rubbish, as its euphuistic title might suggest.

About 1588 three musicians, Byrd, Tallis, and Dowland wrote songs, and these men, along with musicians like Morley, Jones, and Orlando Gibbons, lent to lyric the charm of music. Sidney, Lyly, and Peele had written delightful lyrics before this, but until the musicians came lyric was not always musical. Campion, the great lyrist, was a skilled musician. Students should read Mr. Bullen's edition of the late miscellanies, *England's Helicon* (1601) and Davison's *Poetical Rhapsody* (1602), but the ordinary reader will find the *Golden Treasury of Songs and Lyrics* a most companionable volume.

Summary.—Between Spenser and Milton we find lyric thriving and blank verse decaying. The character of the Elizabethan Age is better discussed under DRAMA, but we may learn something from the poetry of the period. Elizabethan poetry is not didactic; the poet has no message to teach, no "reform" to preach. He is content with life and society, and does not concern himself with prophesying. Realism is conquered by romance. Idealisation of woman and the search for euphuistic conceits go hand in hand. The glory of the period is its song; sometimes it is extravagant, often it is simple in its beauty. England under the Tudors was no Paradise, but Elizabethan song makes it one. The robbing of the peasants under the system of "enclosures" does not seem to have inspired any one to voice their wrongs in song. The poets have eyes only for their lady-loves; their poems are individual, not communistic. Patriotism was not often expressed. Daniel wrote historical poems. Drayton wrote *The Ballad of Agincourt,* a fine war song, but Drayton is at his best in his great sonnet "Since there's no help, come, let us kiss and part"—an expression of personal, not national emotion.

Milton.—We have seen that Chaucer, Spenser, and Shakespeare came to redeem the comparatively bad verse of their predecessors. Milton is the fourth great redeemer of English verse. The blank verse of Shakespeare's successors was weak stuff; lyric alone was good. Milton practically ignored the lighter lyric, but he made of blank verse something grand and noble. Hitherto blank had been dramatic only; Milton used it for epic. He gave to poetry a glorious poetic diction and the great Miltonic organ-music.

In his early poems we see the influence of Spenser and Donne, but he soon leaves behind the exuberant style of the romantic and becomes Vergilian. In nature he was austere and religious in a Puritan sense, and the sumptuous excess of Romanticism was foreign to his nature. He is not medieval; the mere fact that he contemns the Church—a medieval institution—shows that he is a heretic. His "modernism" is treated under PROSE (p. 127).

Milton is a poet of manner rather than of matter. In *L'Allegro* or *Il Penseroso* the subject does not matter; the beauty lies in the treatment. So in *Lycidas,* an elegy on the death of his friend King, he chooses the conventional pastoral, and uses it to attack the Church. Pastorals originally were poems contrasting the free life of shepherds with the meretricious joys of the town-dweller. Poets began to put critical remarks in the shepherd's mouths, so that the pastoral became a kind of satire.

Again, in the great epic *Paradise Lost* and in *Paradise Regained,* the story is of less importance than the manner of its telling. The majesty of the theme, the music of the verses with their euphonious proper names, the thunder of the mighty battles—these give the epic its grandeur. One feature of the story is of high importance—the character of Satan, the real hero of the epic.

Milton's sonnets are important historically. Before his time sonnets usually treated of Love, and were, as a rule, written in sequences. Milton used the sonnet for any subject that occurred

to him. Some of his sonnets are poor; others, *e.g. On his Blindness*, and *On the Massacre in Piemont*, are of the highest rank.

From Milton to Pope.—It should be remembered that the metaphysical poets, Crashaw, Herbert, and Vaughan and the Caroline lyrists Lovelace, Herrick, Carew, and Suckling flourished during Milton's lifetime. Practically all poetry was tinged with metaphysical "conceits." The lyrists kept Ben's classical form, but added fantastic "conceits." One feels that they do not feel deeply; when Carew writes about a fly that blew into the eye of his mistress, and suggests that Love attracted the fly, we know that simple sentiment has been superseded by fanciful sentimentalism. Marvel, who lived a little later, could play the Miltonic trumpet and Caroline flute with equal mastery. In Herrick and Suckling we find a departure from the romantic influence of Provençal love-lyrics. Herrick has no suggestion of the service to woman found in chivalry; and Suckling rejects the chivalric respect for women. It may be said generally that from Ben's time the influence of Anacreon, Catullus, and Horace superseded Petrarchian romanticism in lyric.

Of high importance is the change in the form of verse. The Elizabethan poets were primarily free and exuberant in style; in other words, they followed the excess of Romanticism, not the Hellenism of Classicism. Their followers chose the "correctness" of the classical style; from Cowley and Waller to Pope we find that freedom is eschewed; the heroic couplet becomes more and more strictly moulded, until in Pope we find it a two-lined stanza containing a thought of its own. This change is a direct outcome of the spirit of the new age. The Elizabethans were primarily in love with imagination; then imagination grew weak and poetry became strained with "conceits." The Restoration period was critical, not imaginative; it called itself the age of "good sense."

Under Elizabeth England was a united nation: Englishmen took things for granted; they believed in monarchy, the church, the state. Under the Stewarts and during the Commonwealth England was disunited; the nationalist had become a party politician. People found themselves forced to take sides, hence we find the battles between Anglican and Puritan, King and Parliament, the "Correct" school of poetry and the Romantic school. And we find that poets are now partisans. Waller, Cowley, and Dryden eulogise Charles II; Andrew Marvel satirises Clarendon, and chooses the dangerous subject of the slitting of Coventry's nose. Butler's *Hudibras* satirises the Parliamentarians, and Oldham satirises the Jesuits. Satire was no new thing in England. Jean de Meung's part of the *Romaunt of the Rose* satirised women and the religious orders; Skelton attacked Cardinal Wolsey; Langland satirised Church abuses, as did also the Scottish Chaucerians. Donne wrote satirical poems.

In Butler's *Hudibras* we find the *Rose* elements, the satire on woman and the religious orders—nonconformists.

The age of "good sense" was not inspiring. A poet may find inspiration in Macbeth or King Lear or Satan; he will hardly be inspired by Coventry's ear. The romantic idealisation of a lady-love had degenerated into servile flattery of the Stewart kings. Spenser's flattery of Elizabeth was idealisation; Waller's flattery of Charles II was something less pardonable.

Dryden (1631–1700).—Dryden began by writing poetry after the metaphysical manner, then he took to writing plays (see DRAMA). His third period is the period of his satire, theological poems, and translations. He is a greater satirist than Marvel or Oldham; his *Absalom and Achitophel*, *The Medal*, and *MacFlecknoe* are masterpieces. His great theological poems are *Religio Laici*, and *The Hind and the Panther.*

His importance in the history of poetry lies in his perfecting the satire and in his mastery of nearly all kinds of verse as distinguished from poetry. His heroic couplets are the best of their kind; they are not so rigidly "correct" as Pope's, and consequently have not the same monotony.

If felicity of expression and absence of irregularity in verse make our greatest poets, Dryden stands beside Shakespeare and Milton. But if we require from our poets ideas, imagination, or, combined with complex harmonious metre, passion, Dryden is not of the first rank. In truth the form of his and his successors' art was conventional and fixed; it could be manufactured. The matter only was of value in this Age of Reason.

Pope (1688–1744).—Although "correctness" flourished during the later seventeenth and earlier eighteenth centuries, the couplet was not accepted by all poets. The Restoration lyrists—Dorset, Sedley, Rochester, and Mrs. Behn were writing songs sweet but decadent. Historically, however, the coupleteers are of most importance, and of these Dryden and Pope are the recognised masters. Pope began his career with pastoral poetry, and described the country in the artificial terms of town life. Then in the *Essay on Criticism* he laid down his "correct" views on poetry. *The Rape of the Lock* is truly representative of an age that had eyes for trifling matters only, an age of stupid town gaiety and puerile partisanship and rivalry. After this was written, Pope took to translating Homer, but his famous work belongs to his last period, the period of his *Essay on Man, Dunciad, Satires, and Epistles.*

His couplet is a marvel of neatness and compression; his satire is scathing. So far as form

is concerned, Pope is a great poet. As a philosopher he is "the apostle of the commonplace"; his imagination is negligible; his passion is ruled out by "common sense." He was the conventional poet of a conventional period. "Follow nature," he cries, but he means "For any sake don't do anything original. Nature was fully treated by the ancient Greeks and Latins; their rules were 'Nature methodised'; don't depart from these rules."

Dr. Johnson and Goldsmith were poets of the Popian School, the latter being the last great poet of that school. In Goldsmith we find the Popian couplet, but he has got away from conventional "poetic diction" and describes scenery with freshness and truth. Yet in *The Deserted Village* he is "correct" enough to prevent the poem's being of the first rank.

The Romantic Revival.—The "correctness" of the age of "good sense" could not last. Domination of poetry by the couplet and conventional diction led to a revolt. During Pope's life-time, Thomson's *Seasons* appeared. Though not poetry of the highest kind, the *Seasons* are of the greatest importance historically. They are written in blank verse, and go straight to Nature for their illustrations. In *The Castle of Indolence* Thomson uses the Spenserian stanza. Others were protesting against the "correct" school couplet. Young's *Night Thoughts* was in blank verse; Collins and Gray practised many kinds of irregular measures in pseudo-classical forms, but often with much effect.

We saw how the Elizabethan romanticism degenerated into cheap, meaningless "conceits." The "correct" school of Dryden and Pope came as a rescue. The Elizabethan poets were imaginative dreamers who idealised continually, but at worst they were great artists technically. In the "correct" period idealisation has gone; the poets are realists, although, it must be confessed, poor ones. There is much realism in the satire of the period, but in description realism is lacking and the form of their expression has become standardised. Poets described nature in stock-phrases. "Poetic diction" made poetry ludicrous. "Poetic diction" originally came from Milton.

The rebels who revolted from this arbitrary tradition did not foolishly invent a method of their own. In looking back on their country's poetry they found ready to hand forms of expression which satisfied all their ideals. It was not easy to imitate the form of an Elizabethan lyric. These and other great poems showed few tricks for the pupils to imitate, but they held out countless goals for inspired appreciation.

During the eighteenth century poets shrank from calling a spade a spade; a wood is a "grove," a man is a "swain," the moon is "Diana." Milton's Adam in *Paradise Lost* was the culprit; he called the sun "this diurnal star," and in Pope and Thomson and Gray we find Adam's successors.

The chief feature in the Romantic Revival was the looking back to ancient poetry. In 1765 Percy's *Reliques of Ancient English Poetry* was published, and the eighteenth century made the acquaintance of fine old ballads and lyrics. In 1774 Warton's *History of English Poetry* disillusioned the many Englishmen who believed that the poets before Dryden were worthless.

The Revival is by some dated from Chatterton, who in 1764 began to produce the *Rowley Poems*, which he alleged were the work of a fifteenth century poet. These poems are of the new romantic poetry. In Cowper we see the transition poet; he writes stiff couplets after Pope, and shows the bad poetic diction of the period, but like Thomson he goes straight to Nature for his colours. Crabbe also goes to Nature, and though he uses the couplet he belongs to the new rather than to the old order.

Blake.—When we come to Blake we are beyond the reach of the Popian school. In form alone his poems are as free as Shakespeare's. But Blake's claim to greatness does not rest on his verse forms alone. The twentieth century, the period of realism and naturalism, has discovered in Blake a forerunner of Nietzsche. Blake, sometimes spoken of as "the English Nietzsche," forestalled Nietzsche in declaring that the world should get rid of the idea of sin and punishment. When Blake says "Put off holiness, and put on intellect," "Be yourself," "Energy is the only life," we might be excused for thinking that a Nietzschian is speaking.

Burns.—Almost contemporary with Blake, Robert Burns was writing poems that had no resemblance to the "correct" school work. The Scottish Chaucerians used an artificial literary language, Middle Scots. By the time of Montgomerie, Middle Scots was almost dead. And when Drummond writes he is an English Elizabethan in language and thought. But before Burns wrote, we find Allan Ramsay and Ferguson using dialect in poetry, but it was Burns who raised dialect to a good literary medium. Burns owed much to these two pioneers; Ramsay wrote true pastorals filled with first-hand description of rural life (the Popian school's pastorals were conventional and second-hand); Ferguson, the delicate youth lionised by the Edinburgh smart set, gave vivid poems of Edinburgh life.

Burns's fame rests on his lyrics, but he is not one of the greatest of lyric writers. There is hardly one of his poems which is at once simple without being commonplace, and whose every word or syllable is inevitable, as is the case with the great artists. Our chief thanks are due to him for turning the thoughts of literary people of his time against the Popian couplet.

His execution is not to be compared with that of Blake.

Like Shakespeare he often took old works and rewrote and nearly always bettered them. His poems in English are inferior to his dialect poems, being very stilted in their language.

Blake was a philosopher with ideas ahead of his time; consequently he was known to a coterie only. Burns, as a man of his time, a keen observer, a graphic describer, a malignant laugher, a sweet singer, was lionised in Edinburgh. His idea of freedom is platitudinous; a man who prided himself on being a Jacobite was not a democrat. He was not a deep thinker; he was ruled by heart, not by intellect. Scotland has made Burns a god, just as Britain has made Shakespeare a god. People quote tags like "A man's a man for a' that," and imagine they are quoting great thoughts. Let us grant that he was a genius, though artistically hardly more than inarticulate. He was at his best when he felt most keenly, as in his satirical poems like *Tam o' Shanter*—perhaps his greatest work. Let us love him for his humanity, but let us realise that Robert Burns was no great philosopher, that he wrote poems of democracy without the true democrat's "vision."

Wordsworth and Coleridge.—In 1798 the *Lyrical Ballads*, a book of poems by Wordsworth and Coleridge, was published, and the appearance of this book is generally considered the most important event in the Romantic Revival. The poets explained that Wordsworth's aim was to make the common uncommon, while the aim of Coleridge was to make the uncommon acceptable. Wordsworth chose ordinary subjects, *e.g. We are Seven, The Idiot Boy:* Coleridge chose a supernatural tale, *The Ancient Mariner*, and made it credible and acceptable.

Wordsworth had theories about poetry. He held that poets should use the language of rustics, and when he carries out his own theory he writes drivel like *The Idiot Boy*. He was the enemy of eighteenth century "poetic diction" and all the conventional "town poetry" of the Popians. His attitude to Nature was new. Milton saw Nature through books; Thomson and Crabbe described Nature at first hand. He was a creative poet; he refused to accept other men's subjects and philosophy as Shakespeare and Burns did. Wordsworth described Nature, but to him, pantheist as he was, it was a great spiritual power. Sometimes he would appear to mean "God" when he writes "Nature." He has no passion and no dramatic instinct, but he has profound religious feeling. Much of his poetry is poor stuff, but in *The Prelude, Tintern Abbey*, the *Ode on Intimations of Immortality*, and some of his sonnets, he rises to the highest poetical excellence. The thought is original and profound; the form completely satisfying; the execution inevitable. The result is a complete artistic whole.

Coleridge's fame as a poet rests upon his three dream pieces, *The Ancient Mariner, Christabel*, and *Kubla Khan*. These are unsurpassable for glorious imagery, music, mystery, and suggestion. In his work is that element of strangeness observable in all great poems. Every vowel and consonant in his poems has a value.

Southey (1774–1843).—Nowadays Southey is praised as a prose writer and adversely criticised as a poet. He was not of the first rank, although in *The Curse of Kehama* and *Thalaba* he sometimes glimpses the heights. His popular pieces, *The Inchcape Bell*, the *Battle of Blenheim*, the *Well of St. Keyne*, are commonplace in sentiment and execution.

Scott (1771–1832).—Mere story-telling is not the highest poetry, and, because Scott wrote long narrative poems like *The Lay of the Last Minstrel, The Lady of the Lake, Marmion*, he has been belittled by many critics. But his poetry is not often poor; it has music of a kind, and has done more to tune the ear of the people to riding rhythm than all the works of Wordsworth, Coleridge, Shelley, and Keats. But his music is to theirs as that of Rossini is to Beethoven.

Scott was a sort of Socialist-Tory with aristocratic theories and a democratic practice. He had no class-prejudice; he was at home with all social grades. His chief characteristic was his love for the romantic past; while Byron and Shelley were working themselves into a passion of excitement over the French Revolution, Scott was unmoved. His "heaven on earth" was a dream of the past; Shelley's "heaven on earth" was a dream of the future.

Byron (1788–1824).—Byron, according to foreign critics, is our greatest poet, but this is probably due to ignorance of the beautiful intricacies of the English language. There is too much rhetoric about his poems; he seems to be continually obsessed by a pose. His technique is hardly better than that of the men who write for *Punch*. But his thought gives him a place in the history of poetry, for he is a master of invective and curious satire. His "indignation nearly made him a poet," but he had no restraint, nor had he the inspiration that redeems lack of restraint. His fame among his contemporaries rested partly on his social rank, partly on his egoistical personality, partly on his somewhat shallow philosophy.

Shelley (1792–1822).—Shelley, along with Blake, Wordsworth, and Browning, belongs to that class of artists which is not content to accept current views on morality, religion, economics, and other ideas. Shakespeare, Burns, and Tennyson are of the opposite camp.

Shelley was inspired by the doctrines that produced the French Revolution; the doctrines that have moved all reformers from Prometheus

to Larkin. The poet is the man who cuts keenly, as with a blade of clean steel into the heart of things, and can express his thoughts in great language. That is what we call inspiration. He believed that all men are born free and equal, and that by reasoning and love all inequalities of rank could be abolished. He was a rebel against authority of any kind; he wanted to abolish priests, marriage, and war. His anger against what was established was a vague anger; he saw the rottenness of a social order that was worse than that of our own time. He had no plan for abolishing the evils except a firm conviction that all would be righted by love. But that is of minor importance; poets are not concerned with the details of their Utopias. He had a vision of a better civilisation; he lived for freedom of soul and body. In other words he was ahead of his times.

But great vision and a passionate love for freedom do not make a poet. To these Shelley added a marvellous lyrical power that has never been equalled. His verse is full of word music. Each vowel and consonant does its part like each note of a piano. In the end nothing is forced; all wears the inevitableness of genius. It is impossible to imitate him. His thought is profound, and often difficult to seize because of its delicateness. His descriptions of natural scenery are like a Turner landscape.

Keats (1795–1821).—Keats is one of our greatest poets, but he has not Shelley's keenness of vision; he is concerned with beauty only. In his early work he is over-luscious; he drowns his poetry in sensuous imagery, and not seldom becomes mawkishly sentimental. But in pieces like *La Belle Dame sans Merci, The Ode on a Grecian Urn, Ode to a Nightingale, Ode to Autumn, Isabella, Hyperion, The Eve of St. Agnes,* his odes and sonnets, we find poetry full of gorgeous imagery and haunting music.

Words are often used for the mere sound, and archaisms are not scorned. If you read Keats aloud, mouthing every syllable, you will be rewarded by a great sensuous pleasure. And if you compare his work with that of the pre-Raphaelite painters, who tried to do on canvas what he did in verse, you will realise that Keats was on surer ground.

It is impossible here to consider fully the minor poets of the so-called Romantic School. Some of them are possibly better known to the people than either Shelley or Keats.

Perhaps the most popular poet of the first half of the nineteenth century is Mrs. Hemans, author of *The Better Land, The Graves of a Household,* and many other poems of sentiment or, rather, sentimentalism. The student should read *The Graves of a Household* ("They grew in beauty, side by side," etc.) and then read Shelley's *Ode to the West Wind.* If he cannot see that the former is commonplace in thought and excessive in emotion he should eschew poetry altogether.

Other popular minor poets of the period are Moore, the composer of so many Irish songs; Campbell, the author of *Ye Mariners of England, Hohenlinden,* and other patriotic poems; Thomas Hood, author of *The Song of the Shirt, The Bridge of Sighs, The Dream of Eugene Aram;* Macaulay, the essayist and historian, who wrote *Lays of Ancient Rome.* Less well known are James Hogg (1770–1835) and Leigh Hunt (1784–1859). Hogg, "The Ettrick Shepherd," has a few pieces of real poetry in his voluminous verse; and Hunt is remembered chiefly because his florid style influenced Keats.

The Victorian Poets.—The poets we have been studying all belong to the Romantic Revival. We saw that this Romantic Revival broke the classical correctness and conventionality of the Popian school. The Victorian Age does not break with the Romantic Revival, it is a continuation. The poetry we have been considering is not strictly democratic. Wordsworth in his early work is inspired by the French Revolution; Shelley is the apostle of the idea that led to the French Revolution; Byron seeks after freedom of a kind. But Coleridge and Keats follow mystery and beauty: of the minor poets only one is a true democrat—Thomas Hood.

The Victorian Age is at once democratic and scientific. And science brings scepticism in its train. Darwin's theory of Evolution shook traditional belief in the Creation; Sir Charles Lyell's geological discoveries shook traditional belief in the Flood. Doubt became general, and doubt always involves questioning.

Tennyson.—The spirit of the Victorian period is best reflected in the poetry of Tennyson. He writes poetry around the new ideas introduced by the conflict between science and religion and by the rise of democracy. But he merely puts into poetical language the thoughts of the average man; he has not the vision of a Blake, a Shelley, or a Browning. He suggests what in journalism is called the Nonconformist Conscience.

As a musician and painter in words he is of all but the highest rank. He resembles Keats in his love for beauty and harmony, but it is the love of the beautiful which it was the correct thing for a Victorian man of culture to acquire, and he adds a sympathetic understanding of humanity, that finds its counterpart in the Charity Organisation Society.

His greatest poems are short, *e.g. The Lady of Shallot, Œnone, Morte d'Arthur, The Lotus-Eaters, The Palace of Art, A Dream of Fair Women.* These are full of sensuous colour and sound, but even in these we have the smell of the lamp. In his long poems he is far from successful. *In Memoriam* is a collection of

cairngorms rather than a single large brilliant. *Maud* is marred by its combining good lyric with pseudo-socialistic satire. *The Princess*, though full of songs, is bad as a whole; it tries to combine a Victorian essay on the woman's movement with a frank burlesque. In the *Idylls of the King* Tennyson is out of his element. He did not understand the mystery and morality of the Arthurian Legend. He gives to the legend the Victorian Protestant morality, thereby ruining the story. In Arthur's time there was no duty required of women; the relation between the sexes was governed by Love, not by a conventional moral code. Guinevere was not an adulteress. Tennyson turns a beautiful story into a lesson on morality.

Browning.—In these pages we have continually spoken of the two kinds of artist—the artist who accepts, and the artist who refuses to accept, current thought and morals.

Browning belongs to the latter—the greater class; Tennyson, with Shakespeare and Burns, belongs to the former. While Tennyson was accepting the popular views on religion, science, and economics, Browning was thinking out new views for himself. Tennyson is primarily a painter and musician; the merit of his poetry lies in form rather than matter. With Browning the form is subsidiary; he has something new to say and he says it in an almost spontaneous way. He ignores the reader; his intellect is keen and his pen always lags behind his thoughts. He jumps from one idea to another so rapidly that dull readers cannot follow him; hence the hackneyed talk of Browning's obscurity.

He is not subjective, unless in his dramatic lyrics; his poems are not expressions of personal experience. He is a great novelist in verse. The State does not interest him; he is an individualist; he seeks to discover the secret of the individual's psychology. Love and effort are necessary for living a full and free life; Browning looks for spiritual, not material reforms.

Browning's word-music was at one time condemned as discordant. The present age has advanced beyond the older opinion and recognises music in Browning as it now recognises music in Wagner. The next generation will no doubt smile at the early twentieth century contempt for the "discordant music" of the Futurists.

Browning's wife, Elizabeth Barrett Browning, is known chiefly by two works, *Aurora Leigh* and *Sonnets from the Portuguese*. She has some passion and sensibility, but her poems are marred by her lack of an ear for music.

Arnold and Clough.—These poets are true Victorians in their scepticism. Arnold's *Empedocles on Etna* is a fine example of Victorian questioning; the poet sees faith being destroyed by science and intellectualism, and he takes refuge in an almost indifferent resignation. His *Scholar Gipsy*, *Thyrsis*, and *The Forsaken Merman* are much above the others in poetical form. Arnold's thought makes him a most companionable author. Clough felt more deeply, but could not express himself so poetically. Both are fascinating writers.

The Pre-Raphaelites.—Pre-Raphaelitism, as applied to painting, was a movement to improve the conventional art of the day by a return to the art of painters before Raphael. Applied to poetry, Pre-Raphaelitism is a harking back to medievalism and romance as an escape from the intellectualism and scepticism of the age. The eldest poet of the school was Dante Gabriel Rossetti. He was a painter, and his poems, like his pictures, are mystical and sensuous and peculiarly satisfying. He gave a new turn to the ballad form; he added to its power, but he decreased its naivety. He continues Keats' search for beautiful strange words, and, like Swinburne, he brings out undreamt of values of English sounds. His sister Christina has not his paganism, and she has greater simplicity. She is a great artist in words.

William Morris was primarily an artist. He was a Socialist, but his greatest objection to poverty was that it prevented people from seeing beautiful works of art; he might be called an æsthetic economist.

Like Rossetti, he seeks romance in the medieval past. Rossetti went to Italy for inspiration; Morris turned to the Norsemen's sagas, and he is perhaps unsurpassed as a story-teller. His verse goes with a swing; it is musical and varied, but it never reaches the supreme heights of poetry.

Swinburne, the youngest of the pre-Raphaelite poets, is often called a decadent because he found despair, death, pain, unfulfilled nature, unsatisfied love companionable. It is typical of the man that he has the deepest love of the sea, and of all men he knew its cruelty. Swinburne is one of the lesser rebels; he is anti-Christian and pro-Revolutionary. He is a heretic in his wonderful transformation of ugliness into beauty, and he is always seeking after strange gods. But his vision was besmirched by his education and surroundings. He is classical (*Atalanta in Calydon* is the only English drama in the real Greek manner). He is constantly tending to the pre-Raphaelite notion of painting; he was on the side of Rossetti and Burne-Jones, not Whistler and Manet. As a metrist he is wonderful; he gave poetry a new orchestral music, a new variety in consonantal and vowel sounds.

George Meredith is a greater rebel. Like Browning, his matter is usually greater than his manner, yet his *Love in a Valley* is purely lyrical.

Edward Fitzgerald in *The Rubaiyát of Omar Khayyám* voices Victorian scepticism, and Coventry Patmore ignores both pre-Raphaelitism and intellectualism and writes homely verse. Francis Thompson riots in colour and sound;

The Hound of Heaven is full of purple and gold.

The era of invention and science brings out the verse of Rudyard Kipling. He is the minstrel of Imperialism and strenuousness. His verse has much force and energy, but he is more interesting philologically as a coiner of words than as a poet. He has founded Colonial poetry whose chief factors are unreal, "romantic" subjects, strong language, swinging music.

At the opposite pole to Kipling is Edmund Dowson, chief of the decadents. His *Cynara* and "Exceeding sorrow consumeth my sad heart" are technically most beautiful. The thought is unconventional even to morbidity, but the harmony of their music will never fail to evoke the admiration of literary folk.

William Watson is a true follower of Wordsworth and Arnold, with a slight personal note of his own. Some of his poems are sure of immortality.

W. B. Yeats has added real romance—the element of strangeness—to beautiful though intricate beauty of form. He is a religious poet, as distinguished from one dealing with moral or social aspects. Yeats is the founder of a school of poetry and drama, the chief of whom are Lionel Johnson and Synge respectively. They have drawn no nearer to the real Celtic spirit than O'Shaughnessy and his contemporaries did. "A. E.," another follower, is still alive. Hardy, with a technique not always of the highest, carries into poetry his rebellious pessimism. Robert Bridges, the Poet Laureate, has continued the Miltonic tradition to good purpose, and as a lyric writer ranks in his best moods with the highest. Most of his work, however, is in the nature of poetical exercise.

Masefield's poetry is too often sententious, but his poems have done much good in popularising poetry.

W. W. Gibson and Lascelles Abercrombie are possibly our best modern poets. Gibson sees the world that the man in the street sees; but he throws undreamt of lights on it. Some of his lyrics are the most beautiful things in present day art. His restraint is admirable, his feeling profound, his wisdom simple in its sureness, his use of words inevitable. He does not confuse art with nature. He describes the thoughts and feelings of his characters as Synge does in his plays, not as they would speak in ordinary conversation, but in the words they use in everyday life placed in an order of simplicity they would employ if they were poets.

Abercrombie connects more easily with his predecessors than Gibson does; you often catch a note of Milton in his work. His thought is always very subtle and his psychology difficult. As a metrist he is probably the greatest living.

The best modern poets, Gibson, Abercrombie, John Drinkwater, W. H. Davies, James Stephens, Walter de la Mare, and Rupert Brooke, are not imitators, and are seldom hampered by traditional prejudices about subject or form. They are alive to the world around them; they despise nothing real, but they are not content to state what they see in an inartistic way.

PROSODY

Prosody is the study of the constitution of verse. It is really a breaking up of lines into syllables, and when we break up a line into syllables we are said to scan it. Note the following line:

The | boy | stood | on | the | burn | ing | deck.

This line contains eight syllables, and is said to be an octosyllabic line (Lat. *octo*, eight).

Now each syllable has a quantity; we either lay stress on it when we pronounce it, or we do not. In scansion it is wise to place the symbol ◡, which means "short," above an unstressed syllable, and the symbol –, which means "long," over a stressed syllable. Read the above line aloud and you will find that you emphasize the syllables *boy, on, burn, deck.* The line is therefore scanned:

The boy | stood on | the burn | ing deck.

This brings us to the consideration of "feet." A foot may be monosyllabic (consisting of one syllable), disyllabic (two syllables), trisyllabic (three feet.) Feet of more than three syllables are not often required in English prosody.

Disyllabic feet are of three kinds. An *iamb* consists of a short and a long, *e.g.*

delay, invite, to see, to you.

A *trochee* is a foot having the first syllable long and the second short, *e.g.*

injure, artful, call for.

A *spondee* is a disyllabic foot having both syllables long, *e.g.*

flowed forth, there lies.

Note that the long and short symbols have nothing to do with long and short vowels. The *i* of *in* is short, but if you say "he is in" you can lay stress on the *in*, and in scanning you may write

he is in.

We can now scan verses:

The boy | stood on | the burn | ing deck.

The shades | of night | were fall | ing fast.

Make weep | the eyes | of day

Tempt not | the tyr | ant sea.

Of that | waste place | with joy.

The student need not attempt to memorise the words *iamb*, *trochee*, *spondee*. All he should remember is that disyllabic feet are the commonest in English prosody. But there are other feet—feet with three syllables. The trisyllabic feet in English prosody are the *anapæst* (◡ ◡ –) *e.g.* interfere, and the *dactyl* (– ◡ ◡) *e.g.* cinema.

In scanning it is sometimes better to change a dactyl into an anapæst. Note the following :

Terror | and mys | tery, guard | her shrine, | I

The Assyr | ian came down | like a wolf | on
the fold.

I bring | fresh showers | for the thirst | ing
flowers.

'Tis the mid | dle of night | by the cas | tle
clock.

Merrily | merrily | shall I live | now.

The following line might be scanned in dactyls:

Four for the | quarters and | twelve for the |
hours.

but it is better to start with a monosyllabic foot (*i.e.* a foot of one syllable), and scan in anapæsts.

Four | for the quar | ters and twelve | for the
hour.

Try the same experiment with the previous line,

Merr | ily, merr | ily shall | I live now,

and you spoil the rhythm.

We shall now try to scan a stanza from Stevenson's "Shadow March."

All | round the house | is the yet | black night,
It stares | through the win | dow pane,
It crawls | in the cor | ner,[1] hiding | from the
light,
And it moves | with the mov | ing flame.

Verse lines receive their names from the number of syllables or of feet they contain. We speak of a ten-syllable line as a decasyllabic line (Greek, *deca*, ten), or an eight-syllable line as an octosyllabic line (Lat. *octo*, eight). Again, we can call a five-feet line a pentameter (Greek, *pente*, five, *metron*, a measure). Here is a typical iambic pentameter.

The vill | age mast | er taught | his lit | tle
school.

It should be noted that an octosyllabic line may contain more than eight syllables. We call Coleridge's *Christabel* an octosyllabic poem, because there are four feet in most of the lines, and in ordinary circumstances we count a foot as two syllables.

'Tis the mid | dle of night | by the cas | tle
clock
And the owls | have awa | kened the crow | ing
cock
Tu | whit | tu | whoo !

The first lines have eleven syllables each; the third one only four. In it each foot is monosyllabic. It may be asked, why not scan this line in two feet, thus :

Tu whit—tu whoo !

There is only one reason against doing so: you make the poem irregular.

Blank Verse.—It is scarcely necessary to explain what rhymed verse is. Verse that does not rhyme is known as blank verse, but when we speak of blank we mean unrhymed decasyllables. Knowing this we divide Shakespeare's lines into five foot-spaces when scanning. Take the first lines of *Cymbeline*.

First Gent. You do | not meet | a man |
but frowns : | our bloods

[1] How are we to scan the third line? Suppose we use a foot ◡ – ◡ for ner hid ing.

It crawls | in the cor | ner, hid ing | from the light.

This will not do : there is a distinct pause after *corner*. This pause is called the *cæsura*, and nearly every verse line has a cæsura. Very often at the cæsura and at the end of a line there is an extra syllable, usually called a redundant syllable. You find it in Shakespeare's later plays. Here is a line from *The Tempest*.

And like | this in | substan | tial pa | geant fad | ed.

The *-ed* at the end is an extra syllable. We should look upon the *-ner* of *corner* as an extra syllable, and scan thus :—

It crawls | in the cor | ner ‖ hiding | from the light.

Remember that rules do not matter; let your guide you.

Not more | obey | the heav | ens than | our
court | iers

Still seem | as does | the king |

SECOND GENT. But what's | the
mat | ter ?

Notice that two speakers often contribute to one blank line. The last two lines have an extra-metrical syllable at the end.

Prosody is a subject that we advise the student to wander into without much guiding. Its charm lies in its discoveries. Scan a piece of blank verse from one of the early Elizabethan plays; then scan a part of *Hamlet*. You will conclude that the main difference between Shakespeare and the author of *Gorboduc* is a difference of ear. Again, compare the jog-trot rhythm of Pope's couplets with the freedom of Shelley's lyrics. In general the history of prosody is, like that of nations, a history of freedom's breaking with convention.

But remember that prosody is not the whole of poetry. Any Limerick in a prize competition will scan easily and well, but a Limerick is not poetry. It is possible to be a Keats or a Shelley without knowing the meaning of the word "cæsura."

PROSE

Under the heading STYLE we have explained the difference between plain and ornate prose. In the history of prose style we shall find the two varieties alternating fairly regularly. The weakness of English prose for many centuries lay in the fact that writers modelled the structure of their sentences on Latin. They thought that English would die. Ascham in his *Schoolmaster* writes; "All men covet to have children speak Latin; so do I because there is no other way to bring English to perfection." More wrote his *Utopia* in Latin, and Bacon rewrote his essays in Latin so that they might survive. Hobbes, at the age of eighty-five, wrote his autobiography in Latin verse. In the late sixteenth century we find Harvey, Wilson, Cheke, Sidney, and others defending English and prophesying a future for it, but they are thinking of words, not of structure.

Early Prose.—If we except the *Anglo-Saxon Chronicle*, the earliest O. E. prose of importance is King Alfred's translation. Alfred set out to educate his people, and in translating *Boethius* and *Orosius* he introduced vernacular phrases of his own. The greatest O. E. prose writer was Elfric, who flourished in the tenth century. His work consists of sermons and Lives of the Saints.

O. E. prose could have no future, as the language was slowly dying.

English prose proper began in the late fourteenth century. Chaucer's prose is not of any great merit; it is interesting mainly because blank verse lines appear in it occasionally. Wyclif's prose is important. He was appealing to a lowly audience, and was trying to translate scholarship into the vernacular.

But the greatest prose writer of the period is Sir John Mandeville. His *Voyage and Travaile* shows the first prose style. The author has got away from translation; he leaves religion, philosophy, and history, and wanders into the fields of imagination. The simplicity of the book is delightful; he tells his story as a child would, breathlessly running on in a series of "ands."

The following sentence illustrates Mandeville's simple ease:—"And when she saw that he turned not again, she began to cry, as a thing that had much sorrow."

The next great prose writer is Malory, the author of *Morte d'Arthur*, one of the greatest romances ever written. The music of Malory's prose is wonderful, and the simplicity of the telling is sweet. Here is the conclusion of the farewell scene between Guinevere and Lancelot:

"And the ladies bare the queen to the chamber, and Sir Lancelot awoke, and went and took his horse, and rode all that day and all that night in a forest, weeping."

Another writer of romance was Lord Berners, a master of style. Parts of his *Froissart* remind us of the Book of Common Prayer in their combining Saxon and classical words, *e.g.* "Uphold and sustain." In him we find what is known as "aureate" diction, *i.e.* the use of flowery language, and one of his works, a translation of Guevara's *Dial for Princes*, is believed to have introduced a kind of "Euphuism" before Lyly wrote *Euphues*.

At this time Caxton was printing many romances, and his influence on prose was considerable. He wrote for his own press, and advocated the French style.

A curious writer of the fifteenth century is Pecock. He distrusts classical words, and attempts to find native equivalents; hence we find him using "endly" for "finally," "undeadly" for "immortal."

In Fisher's sermons we find the first deliberate attempt to form a literary style. Like Berners, he uses "tricks" such as the combining of Saxon and classical words, and the use of the triplet (*e.g.* "worldly honours, worldly riches, and fleshly pleasures"). The interest of the prose we have been considering lies in its form, not in its matter. The time of Caxton was one of translation and sermonising; thought was of little importance, for the scholar thought and wrote Latin.

When we come to Sir Thomas More we are in a different atmosphere. In him we see the first sign of the modern spirit—a new indivi-

dualism. He was the first to tackle social inequality. After the Peasants' Revolt in the time of Richard II, labour throve, but in Tudor times sheep-farming drove the rustics into the towns. This event synchronised with the Renaissance of Learning which rediscovered the art and letters of the Greeks and Romans, and opened up new avenues for thought. More is a true product of the Renaissance. He wrote his *Utopia*, a book picturing an ideal state where the inequalities of Elizabethan civilisation were unheard of. He is quite modern; he anticipates Old Age Pensions and the Insurance Bill; he advocates religious toleration; he affirms that punishment should act as a preventative; he wants a six hours' day; he desires to eliminate the idle rich. Yet More is no Socialist. He believes in social ranks; he applies his idea of equality to religion only. He does not do anything to work out his theories in practice. In the main he thinks of morals, not economics. He is a theoretical rebel: he denounces war as being ugly and commercial; he contemns hunting and hawking as being butchery. He has got rid of the foolishness that was named Chivalry.

More was the first to see the utility of Greek thought: his *Utopia* was inspired by Plato's *Republic*. It is noteworthy that Greek inspired many lovers of freedom—Bacon, Milton, Shelley, Byron, Ruskin, and in our own day, H. G. Wells, Gilbert Murray.

As a stylist More is not of high rank. Three other writers of his time are more interesting for manner, if less interesting for matter. They are Latimer, Coverdale, and Cranmer. Latimer was a popular preacher, and he ranks with Bunyan and Cobbett as the chief practitioner of the homely style. Coverdale's *Bible* lent to the subsequent Authorised Version many of its most graceful and musical phrases, while Cranmer is believed to be the author of all that is best in the Anglican Collects and Prayers.

At this period a reaction against ornate Latin diction took place. Cheke imitated Pocock, and tried to coin words. For "parables" he writes "biwords"; for "lunatic," "mooned"; for "alien," "outborn." Yet he liked the Latin construction of sentences, and perhaps taught Ascham to like them also. Ascham was the first to write a definitely plain style.

His prose was excellent for many purposes, but it lacked raciness. The spirit of the times was against sanity of expression; the Elizabethans were all for the exuberance of Romance instead of the quiet order of the Greeks. Lyly came to give the Elizabethans the style they required. He wrote a book called *Euphues*, and his prose style became known as Euphuism. Euphuism was simply a name for the new ornate prose; Euphuistic prose was full of excessive alliteration, impossible images from an imaginary natural history, frequent use of homely phrases and illustrations. It became the fashion. Sidney's *Arcadia* and Shakespeare's earlier plays are full of it.

At the time when Lyly was writing ornate prose, Hooker was writing his *Ecclesiastical Polity* in plain prose. Hooker's prose is almost faultless in balance and harmony, but the writers of his time for the most part followed Lyly. Many translations were made, the most famous being Florio's *Montaigne* and North's *Plutarch;* pamphlets and lampoons became common; Greene, Nash, Lodge, and other dramatists wrote short stories. Euphuism colours all these.

Seventeenth Century Prose.—The age we have just passed was the age of chivalry; the Elizabethan courtier was the true successor to medieval knight. In the seventeenth century the courtier is superseded by the citizen. The imagination of the Romantics was replaced by a modern democratic spirit which was essentially critical. This spirit analysed religious faith and judged time-honoured institutions frankly and fearlessly. In short, literature began to convey facts. Walton and Fuller wrote biographies; the Duchess of Newcastle wrote an autobiography; Pepys and Evelyn wrote diaries; satire, always vague during the Renaissance, became definite.

Bacon.—The new spirit is recognised in Bacon. His "modernism" is seen in a comparison between his *History of Henry VII* and Raleigh's *History of the World.* Raleigh is medieval and monkish, he devotes three chapters to the locality of the Garden of Eden. Bacon is beyond that stage; he is a Romantic, but his Romanticism is intellectual, while Raleigh's is emotional. Bacon's examination of Henry VII's character is unmerciful; it is the first piece of scientific history in English. Bacon as a stylist is great; he is a master of rhetoric, and, like all rhetoricians, he dazzles but does not convince his audience. He is no democrat. He wrote for princes, as his exemplar Machiavelli did. His greatest gift was his desire for inquiry; he was no scientist, yet he popularised science. More in his Utopia pictured a state ideal for living in; Bacon in his *New Atlantis* depicts a state ideal for scientific research.

Jonson.—Ben Jonson, like Hooker before and Dryden after him, is a master of plain prose. In his matter he is mostly concerned with literary criticism, and is on the side of classical order. He distrusts the vernacular as a literary vehicle; he has no sympathy with prose romance. His conservative taste foreshadows the "correctness" of Dryden and Pope and Johnson.

Burton.—The author of the *Anatomy of Melancholy* is typically Jacobean in style like Bacon. He loves long quotations from the classics, and, like Milton, he uses sentences of enormous length. His matter is of little importance to us; it is a dissertation on human melancholy, but its real interest lies in its quiet humour, its profound learning, and its quaint digressions.

Sir Thomas Browne.—Browne, the author of *Religio Medici*, and *Urn Burial*, is one of our greatest stylists. His sentences are full of magnificent music and gorgeous colour. He is a great artist, but is no great thinker. Paraphrase his sentences and, their beauty and sound gone, they are commonplace.

Preachers. — In the history of seventeenth century prose the great preachers play an important part. Usher, Hall, and Donne, Jeremy Taylor, Barrow, Fuller, South, Baxter, and others were famous preachers. From them we expect no great originality; they spent their time expounding texts. Donne and Taylor gave fine music and colour; Fuller a quaint jocular style; South a fine masculine prose.

Character-writers.—A fashion of writing essay-like "characters" grew up in the seventeenth century; the character-writers fixed on a type of person—a braggart, a lover, a pedant, etc.—and wrote a short description of the type. Sir Thomas Overbury's *Characters* are fairly typical. He is no genius; he sees the surface of things. Hall goes deeper, and where Overbury used a hard cynical wit, Hall used genuine humour. Earle is perhaps the wittiest of them all. When he tells us that "a young preacher preaches but once a year, though twice every Sunday," or that "a coward is a Christian merely for fear of Hell fire," he is the Bernard Shaw of the seventeenth century.

Milton.—Technically Milton's prose is poor when compared with his verse. He has long sentences, Latin construction, a laboured vocabulary, and only here and there splendid passages. He writes much controversial prose, and often sinks into scurrility. In poetry he is a conscious artist; in prose he is a pamphleteer. His marriages were unhappy, and he wrote on Divorce; his views on marriage brought him into collision with the censorship of the Press, and he wrote against Censorship; he tutored his nephew, and he wrote on Education. His prose is an expression of his personality.

Milton was original; indeed in some ways he was in advance not only of his time but our own time. He advocated abolition of bishops, the public schools and the universities; he was willing to tolerate polygamy; he wanted to see a republic established. But he was not thinking of democracy; he was thinking of Puritanism. Milton the Puritan saw in public schools and universities hotbeds of Royalism; Milton the genius saw in marriage laws imprisonment of soul. Democracy to him was what it is to the modern party politician—a thing to be led by powerful men.

Hobbes.—The author of the *Leviathan* writes a lucid, ordered style, without any ornaments. His theories about democracy are worth studying; he stumbles upon the great truth that the chief power in a democracy, whatever that power be, is practically irresponsible. This truth constitutes democracy's big problem to-day.

Clarendon.—Clarendon's fame rests on his *History of the Great Rebellion.* His style is bad; he ignores punctuation, and he runs sentences together in batches. His point of view is onesided, but that is no demerit; the historian who thinks he is impartial has no genuine enthusiasm. Truth is best revealed by a fiery fight between two rabid partisans. The merit of the book is vivid portrait painting; he is one of the greatest depicters of character.

Biography.—We have seen that the seventeenth century was much concerned with the character. Ben Jonson wrote on Shakespeare and Bacon; Hobbes wrote an autiobiography in Latin verse; Isaac Walton wrote biographies of Donne, Hooker, and others.

Walton's fame rests on *The Complete Angler,* nominally a treatise on angling, but really a character-sketch.

The chief fault of seventeenth century prose is its lack of directness. Gorgeous imagery, profound learning, musical phrasing we have in plenty, but there is hardly any plain direct lucid writing. When we come to the prose of Dryden, Temple, and Halifax we have arrived at modern prose.

The Age of Dryden and Pope.—This period is sometimes called the *Augustan Era*, because writers imitated the classical writers of the Golden Age of Latin poetry, a time when Augustus was Emperor. From Dryden to Pope writers followed "the ancients"; Aristotle had laid down laws for tragedy and epic, and the English writers thought that these laws were to hold good for ever. Pope says that following the ancients is the same as following Nature. Prose writers, no less than poets, aimed at "good sense," *i.e.* simplicity and conventionality.

The Royal Society was founded to encourage the use of common language, instead of the elaborate Latinisms of previous prose. And no one will deny that English prose required to break away from the Latinised periodic prose of Browne and Taylor.

Modern prose begins with Dryden. There were three editions of his *Essay of Dramatic Poesy* published during his lifetime, and in these we see the changing of idiom. In the first edition he puts a preposition at the end of a sentence; in the third it has disappeared. In the third he writes *written* for *writ*, and where, in the first edition he uses the same word twice in one sentence, he changes one word for another in the third edition.

His prose flows with ease; it is essentially plain and to the point, and it was one of the best models for subsequent writers who wanted to write without wordy rhetoric.

As a literary critic Dryden is ranked high.

When he forgets his "rules" he praises Chaucer; when he remembers his rules he condemns Milton's *Comus* and *Lycidas*. He was no heretic; he preferred to conform to the current mode. As a thinker he was not great.

Bunyan.—John Bunyan is one of our greatest writers. His fame rests upon his *Pilgrim's Progress.* This story is nominally an allegory, but in reality it is a piece of great fiction. The characters are real characters; the psychology is founded on life and experience. Bunyan is a great realist. He has none of the previous period's rhetorical rant; he tells his story in simple manner, but he paints a more vivid picture than the Elizabethans paint.

He is great because he is elemental; he is the great artist who never heard of art.

The Life and Death of Mr. Badman is treated under THE NOVEL (p. 131). *Grace Abounding* is a masterpiece in pessimistic autobiography.

The Diarists.—Evelyn and Samuel Pepys stand apart from the prose writers of Dryden's age. Evelyn's *Diary* is simply a record of events without any accomplished style. Pepys' *Diary* is world-famous, and its fame rests, not on its style, but on its delightful candour and unconscious humour.

Journalese.—About the end of the seventeenth century prose style begins to lose dignity. The philosopher Locke, the pioneer of eighteenth century rationalism, shows signs of colloquial language, but Roger L'Estrange is the recognised scapegoat of the period. L'Estrange, along with Jeremy Collier, the stern critic of an immoral drama, and Tom Brown, wrote in a vernacular manner; they clipped words; they used vulgar phrases; they wrote in the language of the ale-house. The newspaper came on the scene, and in it slipshod language found a refuge.

Defoe.—Daniel Defoe is one of the greatest journalists of all time. He "wrote up" everything that was topical. His fame rests upon his *Robinson Crusoe* (see p. 131). As a thinker Defoe was almost modern. He anticipated modern poor laws, agricultural credit banks, registration of seamen; he sees the cause of bad environment and the fact that there is a law for the rich and one for the poor. As a stylist he ranks with Bunyan as a great master of simple descriptive prose.

Swift.—Jonathan Swift is usually called our greatest satirist. His satire is demoniacally bitter and merciless; his hand is against every man. For him the world was out of joint, but he was not born to set it right. He has no alternative to an evil social system; his genius was that of a destroyer, not a builder.

Steele and Addison.—Steele began the *Tatler* and the *Spectator*, but Addison generally receives most of the praise for the series of essays published in the papers. Steele had much humour and pathos, but he was no genius. Addison was no genius either. He wrote urbane, gentle, manly prose, and he tried to improve the morals of his generation, but he was superficial.

He was too polite to be really important, too conventional to break new ground.

Mandeville.—The author of *The Fable of the Bee* is interesting from a scientific and sociological point of view. In paradox he is the Chesterton of the eighteenth century. He holds that selfishness is at the root of virtue, that social laws are the result of alliances for protection among the weak. He states that "private vices are public benefits," for he believes that the vicious luxury of the rich, by giving employment, benefits the state; a doctrine that no thinking modern would recognise. His writing was an attack on Shaftesbury's idealism.

Berkeley.—To the general reader Berkeley's philosophic works are uninteresting. In the history and prose style he figures as the writer of excellent argumentative prose. His *Essay towards Preventing the Ruin of Great Britain* is easily readable; it is intended to remedy the materialism and secularism of the age.

The Age of Johnson.—*Johnson.*—Dr. Samuel Johnson was a man with a great personality. Consequently we usually think of the subject of Boswell's *Life* rather than of the author of the *Dictionary*, *Rasselas*, or *The Lives of the Poets*. He was the literary dictator of the time; he was the centre of a group that eagerly swallowed his opinions. These opinions were "classical"; the Romantic Revival was alien to Johnson's spirit, although he ultimately came very near to appreciating it.

He was a great literary critic, although hampered by a preoccupation—his belief in Popian "correctness." He fails to see the beauty of Milton's license in *Lycidas*; he contemns the poets who number the "streaks of the tulip." He had no eye for beauty ("one blade of grass is like another" to him); he had no ear for music. But his criticism is always suggestive. He anticipates in a hint what Tolstoy says about Shakespeare—that his popularity is largely due to "custom and veneration."

Goldsmith.—Johnson's prose style is Latinised and pompous. Goldsmith's is its antithesis; it is light and graceful. Goldsmith is a typical Irishman; he has wit, humour, heart, and an indulgent view of Englishmen.

Burke.—Edmund Burke is one of the chief members of the Johnson circle. His prose is oratorical, and for imagery, music, and architecture is unsurpassable. As a politician he was opposed to democrary; he believed that the aristocratic few must govern the vulgar many. He believed in a gradual evolution of nations, and naturally was appalled by the French Revolution. He had vision; he foresaw the loss of the American Colonies; but his failure to grasp the significance of the French Revolution shows that his vision was limited.

The Historians.—History in England had not been of much literary importance previous to the eighteenth century. Raleigh had written his *History of the World* in a medieval manner; Clarendon had produced his *History of the Great Rebellion*, a biassed and consequently important work.

The historians of the eighteenth century are Hume, Robertson, and Gibbon.

Gibbon.—The greatest of the three is Gibbon, the author of *The Decline and Fall of the Roman Empire*. Like Johnson and Burke, Gibbon writes plain prose with ornament superadded. As a historian he paints great pictures, and like Clarendon he has a bias. Clarendon hates republicanism; Gibbon hates Christianity and the enthusiasm of any religion.

Adam Smith.—The most important among the other prose writers of the Johnsonian period is Adam Smith, author of the *Wealth of Nations*. His prose style is not specially distinguished. The *Wealth of Nations* is one of the great works on political economy. It came as a heretical treatise; it attacked the economical theories of the past. To many students of the present day it is unsatisfactory; it does not reach towards the ideal state, where there are no landlords or idle rich. But Smith's theories have had an enormous influence in the evolution of the science of economics.

The Rise of the Periodical.—From the time of the character-writers the essay had flourished in one form or another. In the hands of Jonson, Bacon, Dryden, Addison, and Steele, it had treated most subjects. At the beginning of the nineteenth century the essay was given a new vogue by the inauguration of the *Edinburgh Review*, the journal of Jeffrey, whose criticisms of the Lake poets made him notorious as a bad critic. "Christopher North" (Professor Wilson of Edinburgh University), the author of *Noctes Ambrosianæ*, wrote for *Blackwood's Magazine*. Lockhart, Sir Walter Scott's biographer, was editor of the *Quarterly*. Thomas Hood was sub-editor of the *London;* Lamb, Leigh Hunt, and De Quincey all contributed to periodicals.

Lamb.—Charles Lamb is one of the most lovable personalities in literature. A mild, nervous, whimsical man, he wrote mild, nervous, whimsical essays. He gossiped in print. As a critic he has been much lauded. His appreciation of Shakespeare was great, but unfortunately Lamb's example, together with that of Coleridge and Hazlitt, has led to Shakespeare's being judged by his single passages rather than by his plays as a whole.

Hazlitt.—William Hazlitt ranks with Coleridge and Lamb as a great literary critic. All three had an enthusiasm and egotism that is absent from Steele and Addison. Lamb was an amiable man; Hazlitt had a vile temper. In his criticism one finds judgments that are warped by personal whim, but he was a fine critic of passages. His *The English Poets* is full of suggestion, although marred by his contempt for history.

De Quincey.—The author of the *Confessions of an English Opium-Eater* lives chiefly as a stylist. His manner is more important than his matter. He revolts from the plain prose, and writes poetical prose, full of imagination and sound.

Cobbett.—Cobbett's one claim to figure in a history of English prose lies in his carrying on the tradition of Latimer and Bunyan in using a vernacular style.

Southey.—Southey's prose looks back to Addison; it is fine but correct after an eighteenth century fashion.

Macaulay.—Macaulay is one of the student's early loves. His graphic short sentences and his forcible exaggeration appeal to the young. As a historian he is good, because biassed; as a thinker he is narrow; as a journalist he is excellent.

The Victorians.—*Carlyle.*—Carlyle's imagination was deeper than Macaulay's. His style is proverbial; it ignores parts of speech, it uses inventions like "beautifuller," it uses nouns as verbs, verbs as nouns. Carlyle is no constructive thinker; he is emotional, not intellectual. His red-hot vehemence of expression is subjective, not objective. He glorifies work and duty. Nevertheless he is a great writer.

Macaulay and Carlyle were the first of a group of historians—Buckle, Freeman, Green, and Froude. Buckle held that environment made the man (Carlyle held that the great man made the age); Freeman was polemical and bitter; J. R. Green was picturesque and imaginative; Froude was inaccurate, but a great painter in words.

Arnold.—Matthew Arnold is generally lauded as a great literary critic. His merit is his suggestiveness; he uses the comparative method, *i.e.* he ranges through ancient and modern literature, and judges English work in relationship to Greek, Latin, French, German works.

Ruskin.—Ruskin's work is primarily concerned with art, and art to him means Turner. Undoubtedly he had a great vision; that the Futurists in art and economics are beyond him does not alter that fact. His style is ornate (sometimes metrical) and very musical. Latterly he believed in a kind of aristocratic Socialism.

Pater is a notable stylist in the pictorial manner. His merit as a critic lies in his frank search for beauty.

From Pater's time onwards, style in itself is not specially considered. The writings of Darwin, J. S. Mill, Huxley, Hugh Miller are, for the most part, specialists' treatises. Newman alone stands out as a master of prose style.

It is impossible to mention many of the recent

writers of English prose. One of the most individual was Oscar Wilde, who wrote brilliantly witty and paradoxical plays and essays (*e.g. Intentions*).

THE NOVEL

A novel is a story in which the characters are fictitious; even if a historical personage is introduced, he or she is made to develop a character of his or her own.

As we have action plays and psychological plays, narrative poetry and philosophical poetry, so we have story novels and psychological novels. H. G. Wells's *Marriage* is a novel; so is his *The Invisible Man*. But the two are miles apart in style and motive. *The Invisible Man* is a story; its interest lies in its adventure and surprise; we are interested in the plot—how the story will end. In *Marriage* the plot is of minor importance. There is no stirring adventure; the development of the characters is our main interest. *Marriage* deals with souls; *The Invisible Man* deals with incidents. The best novels are of the *Marriage* order. Readers of Meredith, Hardy, Wells' (in his later works), Bennett, and Locke are bored to death by the tales of absurd adventure that pour from the libraries and run as serials in the commercial press.

A taste in fiction comes after much reading only. The schoolboy who commences his reading with "Penny Dreadfuls" will not be long before he desires something better. The wise parent will not forbid his boy from reading "Dreadfuls"; he will be glad to see a desire for reading manifesting itself, and, when the time comes, will gently lead the young reader to a better pasture.

It is a mistake to read good fiction when you are very young. Give a schoolboy one of Meredith's novels, and ten years later he will in all likelihood say "Meredith? I can't stand him. I once read *The Egoist*, and I thought it a poor story." The present writer read Sarah Grand's *The Heavenly Twins* when he was very young, and all he saw in it was an idyll of a sweet girl and a beautiful-natured Tenor. Years afterwards he re-read the story, and was surprised (and delighted) to find that the book was a great argument and plea for woman's freedom.

The average youth begins with "Penny Dreadfuls," but he soon goes on to Ballantyne and Kingston. Ballantyne is moral and religious, and because of this most schoolboys prefer Kingston. Tales of schools also belong to an early phase; most boys enjoy the stories of Ascot R. Hope and Talbot Baines Reed, author of *The Fifth Form of St. Dominic's*. Kipling's *Stalky and Co.* is too realistic for most boys, and it is best read when a boy is seventeen at least. The next period is one of romantic tales of adventure. Guy Boothby is a general favourite with youth; his delightful method of beginning a story with a "Hands up, or I fire!" kind of sentence wins a boy's heart at once. During this period a youth reads Stevenson's *Treasure Island*, Anthony Hope's *The Prisoner of Zenda*, and its sequel *Rupert of Hentzau*. Stanley Weyman's *A Gentleman of France*; Rider Haggard's *Montezuma's Daughter* (and Kingsley's *Westward Ho*, which tells a similar story), *King Solomon's Mines*, *She*; Cutcliffe Hyne's *Captain Kettle*; Conan Doyle's *Adventures of Sherlock Holmes*; Kipling's *Kim*.

The transition from the adventure tale to Hardy or Meredith is difficult to follow. Possibly Marie Corelli's books, by their constant criticism of society, give many young people a taste for deeper criticism and thought, just as Ella Wheeler Wilcox's poems lead people to the study of good poetry. We have suggested that the psychological novel is greater than the adventure tale, but we do not intend to give the impression that we despise adventure tales. A romantic story like Mary Johnson's *By Order of The Company* makes excellent reading. Unfortunately, however, many readers never get past the romantic novel; their one desire is for thrills. That this class of reader is a large one is shown by the cinema-houses' offering of large doses of sentimental pathos and absurd heroic adventures, in which, of course, the ending is happy.

It will be noted that the classics are not mentioned in the above list. The classics either enter into a boy's reading incidentally, or they never enter at all. Occasionally a boy will take a fancy to Scott (many boys are repelled by his dry introductions), or to Dickens or Thackeray. The works of the Brontës, Sterne, Richardson, Fielding, George Eliot do not belong to any special phase. In general the modern reader does not want to read the classics; there is in this age a desire for the new books and the new theory. Professor Sir Walter Raleigh's opinions of Shakespeare are of more interest to the present writer than Hazlitt's are. This modern desire for the "latest" is inimical to education, and our universities, by ignoring Arnold Bennett and dwelling on Lyly and Fielding, play a necessary part as correctives. Where our university professors fail is in their forgetting that modern known writers should be constantly compared with ancient unknown writers. A professor of English Literature will discuss More's *Utopia* and hark back to Plato's *Republic*, but he will not compare More's work with Wells' *A Modern Utopia* or Morris's *News from Nowhere*.

The same objection may be taken to the teaching of History in schools. History, for most children, stops at the Revolution of 1688; after that History means Marlborough's wars, the "'Forty-five," the Crimean War, and the Indian Mutiny. Few teachers would think of mentioning Larkin in a lesson on the Peasants' Revolt of Richard II's reign.

To sum up, study of modern men and books only is bad; study of dead men and books only is bad. Education requires a blending of ancient and modern.

History of the Novel.—The word "Novel" proper came from Italy. Boccaccio in 1350 wrote *The Decameron*, a collection of prose tales ("Novella Storia") of adventure.

Italian fashions soon become popular in England, and Italian stories were translated (*cf.* Painter's *Palace of Pleasure*). The novel must not be confused with the verse romance; the romance dealt with legendary figures, the novel dealt with real figures.

The first novelist was John Lyly, who wrote a novel called *Euphues, The Anatomy of Wit* (see p. 126). Nowadays *Euphues* would not be classed under fiction in a public library, for it is really a book of moral aphorisms with the flimsiest of plots. The dramatists Greene, Nash and Lodge wrote Euphuistic stories dealing with the London low life of the day. Nash points the way to Fielding; his *Jack Milton* has characteristics in *Tom Jones*.

Sidney's *Arcadia* is a pastoral romance, with less realism than the tales of Greene and Nash, but it is an advance on *Euphues* in characterisation.

During the dramatic outburst the novel was moribund. Dekker wrote stories with lively pictures of types, but he wrote better plays. It would appear that the novel and the drama cannot flourish side by side on equal terms. The nineteenth century was the period of the novel, but nineteenth century drama in England was wretched stuff. The twentieth century promises to be a great dramatic period in England. We find that the novel did not become important until drama was decadent. But the Elizabethan paved the way for the psychological novel—that is, the novel where character, not incident, is predominant. Men became introspective; the lyrics of the dramatists are personal expressions. And a strong desire to study men's "humours" and "characters" led to Ben's humour comedies and the characters of Overbury, Hall, and Earle.

Bunyan.—*The Pilgrim's Progress* is a novel of adventure, but it is also an introspective study of the writer's soul. Christian is Bunyan. It is a great story, full of great passages. Think of the simplicity and force of the following passage:—

"Then Apollyon straddled quite over the whole breadth of the way and said, 'I am void of fear in this matter. Prepare thyself to die, for I swear by my Infernal Den that thou shalt go no further. Here will I spill thy soul!'" There is no trace of the dramatists' bombast and rhetoric here. *The Life and Death of Mr. Badman* is more modern than *The Pilgrim's Progress*: it foreshadows the novels of Richardson, Fielding, and Thackeray.

Defoe.—Daniel Defoe was a born storyteller. His imagination always runs away with him, and, when he writes his *Journal of the Plague Year*, he is inventing quite as much as he does when writing *Robinson Crusoe.* He anticipates moderns like Reade, Dickens, H. G. Wells in using fiction as a means of satirising social evils. *Robinson Crusoe*, it must be remembered, came at a time when the French "heroic romance" was popular, and its naturalism did much to kill the impossible adventure stories that led Dryden to write his "heroic" ranting play *The Conquest of Granada.* Defoe's novels had two faults, they lacked humour and sentiment.

Swift's *Tale of a Tub* and *Gulliver's Travels* are satires with just enough story to make them novels. And Johnson's *Rasselas*, though nominally a novel, is simply literary criticism put into the mouths of characters who do not really live.

Richardson.—Richardson's novels are written in the form of letters. *Pamela* is full of mawkish sentimentality. *Clarissa Harlowe* is one of the great studies of feminine psychology. *Sir Charles Grandison* is a prolix study of a prig. Richardson is always trying to be moral in a conventional sense; he is far too long-winded; he is devoid of humour. His great merit is his knowledge of feminine nature and human motive.

Fielding.—Fielding had a strong sense of humour. He began by parodying *Pamela* in *Joseph Andrewes.* He is superior to Richardson in character-drawing and in construction. In *Jonathan Wild* he showed himself a fine satirist, but he is at his best in *Tom Jones.* This work is not immoral: it is merely coarse. There is a healthiness about Fielding's obscenity that Richardson's moralising does not possess. But Fielding is a painter rather than a prophet. He accepts current ideas of morality; he is on the side of the man, and does not foresee a time when the woman will demand from men the same standards of morality that men apply to woman. He owed much to the Spanish picaresque novel, or rather that great parody of the picaresque novel, *Don Quixote.*

Smollett.—Smollett also was influenced by the Spanish novel. He is not one of the greatest novelists; he excels in animal spirits and sailor portraits. *Humphrey Clinker* is his best work.

Sterne.—The author of *Tristram Shandy* is one of the great humorists of English literature. He has not the broad humour of Fielding or Smollett; his is the rapier thrust, not the broad-stroke blow.

Goldsmith.—*The Vicar of Wakefield* is an idyll; it is a simple sentimental story told in a charming way.

The Women Novelists.—The first woman novelist of note is Frances Burney; her *Evelina* (1778) gives a lively picture of eighteenth century

society. Mrs. Radcliffe wrote of secret passages, mysteries, and the supernatural, and brought the Romantic love for Nature into English fiction, but had no claim to genius.

Jane Austen.—Jane Austen lived all her life in a sleepy country town. Her work is an advance on what was a conventionalised fiction; she has no melodramatic titled villains nor abductions. Her women characters are better psychological studies than Richardson's; her sentiment is saved by her sense of humour from becoming sentimentalism. She is always mildly satirical and impersonal.

Maria Edgeworth and Miss Ferrier are of no great importance; the former could paint Irish life and manners well, and the latter is sarcastically delightful in depicting the Scotch gentry.

Scott.—Sir Walter Scott's general outlook on life is discussed on p. 120. Here we are concerned with the novelist. Scott came at the time of the Romantic Revival, but this circumstance does not account for his romantic stories of the past. It was his temperament to dwell in the past, just as it was Shelley's temperament to dwell in the future.

Scott practically created the historical novel; previous writers had used history without truth or accuracy of detail. He admitted that Miss Porter's *Scottish Chiefs* (1810) and Maria Edgeworth's studies of Irish life led him to combine history with national (Scottish) character. Scott can tell a story excellently; he can paint lively characters, and describe nature realistically. He has no bias, and in consequence he has no propaganda; he accepts current views on morality and behaviour. He is on the side of Romance. The French Revolution inspired Wordsworth and Shelley; it made Scott tired, and he sought refuge in the romantic past.

Contemporary with Scott was another Scottish novelist—John Galt, who lives because of *The Annals of the Parish.* Galt is no genius like Scott, yet he was nearer to the life of his time than Scott was. While Scott was telling tales of Ivanhoe and Robin Hood, Galt was depicting the industrialism of his own town.

Among Scott's successors in romantic fiction were James Grant, author of a *Romance of War*, and Bulwer Lytton, famous as the author of *The Last Days of Pompeii.*

Charles Lever lives by reason of his rollicking extravagant military tales *Charles O'Malley* and *Harry Lorrequer*, and Captain Marryat's *Peter Simple* and *Mr. Midshipman Easy* are immortal as boy's stories.

Thomas Love Peacock wrote the novels *Headlong Hall, Nightmare Abbey, Melincourt*, and others. He lives in the period of the Romantic Revival, but he always looks back to the cheaply ironic eighteenth century period.

The Victorian Novel.—*Dickens.*—Charles Dickens is one of our greatest novelists. He can tell a story, or draw a character excellently. He has a great gift of humour, but his pathos is too often sentimentality; some of his pathetic scenes are as mawkish as any cinema "moving drama full of human interest."

Dickens was essentially plebeian; he was a true son of the working-class, and never became a snob. But, democrat as he was, he lacked vision. One feels, in reading his novels, that he accepted Victorian current views on morals and politics. His attitude to social abuses was that of the Liberal rather than that of the Socialist. He had definite ideas of good and evil. He was a romancist in his general outlook, and a realist only in details. Consider *David Copperfield.* In drawing Steerforth, Dickens is following the time-honoured prescription that a seducer of a woman is a bad man who deserves punishment—poetic justice. Again, think of Dora Copperfield. Think of the manner in which a modern—say, H. G. Wells—would have treated her. Probably he would have had hundreds of pages giving David's introspective musings on his marriage to a woman whose temperament was incompatible with his own. Possibly he would have made David run away with Isabel.

We are not trying to hint that Wells is greater than Dickens as a novelist. He isn't; but he is a greater thinker. His characters try to find out what is good and what is evil in an environment that is compounded of convention and law. Dickens accepts the convention and law; he accepts what the man in the street thinks good or evil.

Thackeray.—Thackeray resembles Dickens in this, that he accepts the current code of ethics. He differs from him in nearly every other respect. His sense of humour is different; he is a wit rather than a humorist. You smile with Thackeray, but you guffaw with Dickens. His outlook is different; to him Society means the upper and middle classes. Dickens had too much humanity to be a good satirist; Thackeray had too little. He has often been praised for his satire. Personally we fail to discover on what his fame is founded. He was a Victorian W. S. Gilbert—only much greater. His *Vanity Fair* is scarcely a more cogent criticism of society than *Vanity Fair* the popular weekly is. Thackeray did not look deep; any satire he has is surface satire. But he is a great novelist and stylist, although he falls below Dickens in wide humanity.

The Brontës.—Charlotte Brontë, the authoress of *Jane Eyre*, has one great merit; she gives us an introspective study of herself. True, she almost fails when she invents other characters, but we do not mind that. She belongs to no school; she blends romance and realism, sentimentalism and domesticity. Her sister Emily is much greater in imagination; as a piece of

"fiction," *Wuthering Heights* is greater than *Jane Eyre*. Mrs. Gaskell, who wrote the life of the Brontës, is for the most part an inferior novelist; she sees the obvious and little more.

George Eliot.—There are many modern people who find George Eliot's books dull, and you will probably find that *Adam Bede* and *The Mill on the Floss* are seldom asked for at Mudie's. Her present unpopularity may be due to the undoubted fact that she is at best a second-rate novelist. She has plenty of humour; she is "advanced" in a Victorian sense; she is always a critic; she is a fine painter of rural scenery; she subordinates more incident to character. But she fails to arrest the twentieth century, possibly because hers is the talent of experience and observation, not the genius of creation.

There is nothing very arresting to be said about Charles Reade, Anthony Trollope and Charles Kingsley. Each could tell a story very well, and the former had a didactic purpose.

Modern Fiction.—The works of Dickens mark the transition stage between the Victorian and twentieth-century novel. Thackeray's tales afford shallow moralising, but Thackeray was not frankly didactic. Dickens was.

Again Dickens is a half-century ahead of Thackeray in his choice of atmosphere. Thackeray followed the Aristotelian tradition of making his characters people of birth; Dickens pointed the way to the fiction that was to produce *Kipps* and *The House with the Green Shutters*.

In general it will be found that the best modern fiction has no special predilection in its choice of atmosphere; it is frankly eclectic.

George Meredith stands out as the first master of the new fiction. He has no mission; the only social questions that attract him are Home Rule and the emancipation of women. He loves humanity, and has Browning's passion for studying types. He owes something to Carlyle in style, and something to Thackeray in treatment of character, but he is mostly original.

Thomas Hardy is possibly as brilliant an analyst of character, but his art is less perfect. Meredith's characters work out their own salvation; Hardy's are the victims of simple chance. Tess and Jude the Obscure never get a chance. Again there is an elementariness about Hardy sometimes. *Two in a Tower* shows this, both in style and treatment of character. Another strange circumstance is that books like *Far from the Madding Crowd* and *Jude the Obscure* appear to be romances that have lost their way. When you read them you think them grim pieces of realism; a month later you think them romances.

George Moore is frankly realistic. His *Mummer's Wife* is one of the greatest novels ever written. Moore eschews all sentimentalism and make-believe; he seeks truth, not at the bottom of the well, but at the bottom of the cess-pool. He finds it, and the wonderful thing is that it is often beautiful.

One should compare Moore with George Douglas, the brilliant young Scot, who wrote *The House with the Green Shutters*, in our opinion the greatest novel Scotland has produced.

There is very little beauty in this book. The only touch of humanity in it is where the baker cries: "Damn it, man, leave folk alane," when the rotten-hearted Deacon is baiting Gourlay in the Skeighan brake. All else is ugly spite and hate.

The main characteristic of the novel is power. Douglas is a master of words; with one word he will paint a canvas.

It is impossible to mention more than a very small fraction of present-day novelists. George Gissing has often been praised for his realism and thought, but he is not at all profound. His novels are full of moralisings about social grades, but one cannot help feeling that Gissing's ideal is a life of respectability in a London suburb.

H. G. Wells began as a writer of imaginative novels dealing with science. Then he added humour of the most delightful kind, and gave us books like *The Invisible Man*. Later he took up the novel of sex psychology. . . . *The New Machiavelli*, *Marriage*, *The Passionate Friends*, *Tono-Bungay*, *Ann Veronica*, *Love and Mr. Lewisham*, and others. The interest of these is sociological in the main; Wells places his lovers in a garden-party where futility reigns, instead of in an Arcadia. In the end, however, they generally have the moral courage to fly to Arcadia in spite of Mr. Wells. Every one of his later works is a gold mine of suggestion and thought.

Conrad belongs to the class of novelists who write narratives. He deals with what he has seen in his travels. He is a master of the telling word and the illuminating phrase.

Another word master is Rudyard Kipling. He is a man with a mission; he advocates an Imperialism that, to many, means an aggressive forcing of British Commercialism and Toryism upon other races. He is the apostle of efficiency and discipline. As a short-story writer he is great.

It has been said again and again that Kipling's Muse is dead. The truth is possibly this:—He has outlived his time. The present age is the age of the democrat. Kipling is essentially aristocratic and oligarchic; his works do not hint that he believes in democracy.

Arnold Bennett, one of our most prolific writers, has published some very companionable novels. He favours the narrative type of story. His characters are more or less conventional; they adapt themselves to the universe, while Wells' characters are always trying to adapt the universe to themselves.

Perhaps Bennett's fame will rest on *The Card* and its sequel *The Regent*, two of the funniest books of the century.

W. J. Locke is another novelist without a mission. His characters are mostly realists who move in a romantic atmosphere; Marcus Ordeyne is a man with a wing collar and coloured socks, walking abroad in the Forest of Arden.

We must make some reference to what is known as the Kailyard School. Some have placed Stevenson in this school, but he is a long way from men like Ian MacLaren and Crockett.

Stevenson began as a romancist, and he discovered romance in everything. Yet, had he lived, he might have been a great realist. The unfinished *Weir of Hermiston*, his greatest work, has nothing of the *Treasure Island* manner about it; it is a fine study in psychology.

The novels of the Kailyarders are mostly novels of sentimentality. Barrie is undoubtedly the greatest of the group, but he does not always reach the heights. *When a Man's Single* is weak stuff. *Sentimental Tommy* and the sequel *Tommy and Grizel* form a great work which is marred by the absurdity of Tommy's death. Possibly Barrie killed Tommy because he didn't know what to do with him.

One work of Barrie's is a perfect whole—*A Beautiful White Bird*, one of the sweetest stories ever written.

A special word must be said about the humorists in English fiction. Dickens stands at the head of modern humorists, and it can be seen that W. W. Jacobs has many of Dickens' tricks and mannerisms. Jacobs is a fine humorist, but his humour lies in the manner of telling. Stage a Jacobs story and its humour is gone. Barrie on the other hand is a humorist because he picks out the scenes from life that one would laugh at. Hence his humour stages well.

Jerome K. Jerome's humour is out of date; it is too far-fetched.

George A. Birmingham is delightful, and Stephen Leacock is great at times. Three novels full of exquisite humour are *Kipps*, by H. G. Wells, *Septimus*, by W. J. Locke, and *The Card*, by Arnold Bennett.

DRAMA

In drama there are two main divisions, tragedy and comedy.

Tragedy.—The word tragedy, thanks to the newspaper reporter, has become the accepted term for a murder. Newspaper headlines blare forth such words as "Awful tragedy in Poplar; man shoots wife and four children," and the average playgoer naturally thinks that a tragedy is a play with a death at the end. The use of the word "tragedy" for a crime is misleading; indeed in Tragedy a murder is always something greater than a vulgar crime.

Aristotle the Greek philosopher and critic said that in tragedy the chief character, owing to some human frailty, meets with disaster. He is neither a very good nor a very bad man; if he were very good his disasters would horrify us; if he were very bad we should say "serve him right." But when he is a man of normal qualities his troubles rouse our pity and awe.

Tragedians since Aristotle's time have put his theory into practice, although many of them never heard of Aristotle. The heroes of Shakespeare's tragedies are neither saints nor sinners; they fall because of human frailty. Hamlet's tragedy is his failure to rise to an occasion; Macbeth is a fairly good man, and his tragedy is his being led into a situation he cannot fill; Othello's tragedy is his fancied discovery that purity is non-existent.

Yet perhaps the idea of circumstances, of Fate, is of greater importance in tragedy than human frailty. Macbeth's weakness would not have led him into trouble if Lady Macbeth had not been ambitious. And Lady Macbeth was a potentially good woman overpowered by Fate. Fate, in the person of Iago, overpowers Othello. In Ibsen's *Ghosts* human frailty accounts for Mrs. Alving's tragedy, but her son's awful end is the work of Fate in the form of Heredity. So in Masefield's *Nan* the heroine is a good girl with no special frailty; her tragedy depends on the weakness of others—the hate of a she-devil and the treachery of a youth—and on the circumstances of her parentage.

Aristotle held that the chief character in a tragedy must be of exalted rank, because the higher a man's rank the more appalling his fall. Shakespeare makes his tragic heroes men of high rank, but modern tragedy counts on human life, not on social standing. Nan is of the common people.

Comedy.—The generally accepted definition of a comedy is "a play that makes you laugh." This definition is inadequate. *Charley's Aunt* and *When Knights were Bold* make you laugh uproariously, but they are not comedies: they are Farces. A Farce is "a play that makes you laugh"; it is full of ludicrous situations entirely divorced from any situations of real life.

A comedy is, strictly speaking, a light, tolerant satire on current manners, customs, morals, politics, &c. It is essentially a criticism of contemporary life. It depends upon its wit rather than on its humour; we smile at comedy, but we roar at farce.

It is necessary to distinguish between wit and humour. When a low comedian tumbles into the orchestra we laugh: the incident tickles our sense of humour. But when a character in an Oscar Wilde or a Shaw play says brilliant things we smile: the sparkling dialogue appeals to our sense of wit. Humour belongs to the heart; wit is an intellectual exercise. The rustic whose intellect is not developed will see

no point in Shaw's dialogue, but he will thoroughly appreciate an old man's slipping on a banana skin.

Comedy therefore is the product of a more or less cultured society. It usually deals with town life and dwells upon social amenities.

Plays cannot be definitely classified as Tragedy or Comedy. Various hybrids have grown up. We have Shakespeare's Historical Play and Romantic Comedy, Dryden's Heroic Play, the modern Melodrama (a play depending upon exciting incident and romantic plot), the Psychological Play (*e.g.* Ibsen's *The Doll's House*, which is neither Comedy nor Tragedy), the Opera, and the Comic Opera. Musical Comedies and Revues are not drama : they belong to the order of music-hall entertainments.

Early-English Drama—*Miracles and Mysteries.*—English drama, like Greek drama, was religious in origin. The destruction of the Roman Theatres resulted in the *mimis* becoming travelling "turns." The ill-favour of the Church followed them, but in spite of opposition they throve. Gradually they organised themselves into guilds, and civic corporations took them over. The Church at length saw that the *mimi* could not be ignored, and it issued edicts telling the people what shows to attend and what ones to eschew.

Possibly the Church began to see that the play might be used as an educative force. At any rate we find that by the twelfth century the clergy had begun to give dramatic performances on special feast days. They acted stories from the lives of the Saints and from the Bible ; the former are known as Miracles, the latter as Mysteries. Gradually the Miracles passed out of the Church into the street ; the priest was superseded by the layman—the member of the guild.

The Miracle plays were written in cycles, and four cycles have come down to us—the York, Wakefield, Coventry, and Chester plays. None is earlier than the fourteenth century. The plays in these collections show how drama develops from a Church spectacle to something related to the life of the time. Secular incidents are introduced into sacred story and these are generally humorous.

A typical play is *Noah and the Flood*, which was played by the guild of Fishermen and Mariners. Noah tells his wife to come aboard for he is about to set sail. She refuses and the two begin an argument that leads to blows. In the *Second Shepherd's Play* a sheep-stealer Max is introduced as a clown. The clown was a development of the Devil of the Church Miracles.

The Morality.—The Morality was a play with allegorical characters (*e.g.* Experience, Studious Desire), and its aim was to teach. The Morality did not supersede the Miracle : the two continued to exist side by side. The characters of the Morality were not interesting, but gradually real human characters with allegorical names were invented.

The Interlude.—The Morality was intended to teach ; the Interlude was a mere piece of farce. A typical example of the Interlude is Heywood's *The Four P.'s*. In this a Palmer, a Pardoner, a Pedlar, and a Poticary have a competition to decide which is the greatest liar. The fact that the Palmer wins is merely a mild instance of early satire against the Church.

Tragedy and Comedy.—The Miracle, Mystery, Morality, and Interlude were entirely native products, but about the middle of the sixteenth century, Englishmen began to study the Latin plays of Seneca. The Senecan type of play did not represent action on the stage ; action took place "off," and a Messenger rushed on to tell the tale. The Classical Messenger had appeared in *The Four Elements*, an Interlude, and this is perhaps the earliest sign of classical influence we have.

The first English Tragedy is *Gorboduc*, a Senecan play by Sackville and Norton. It was an appeal in drama to Elizabeth, begging her to marry so that there should be no dispute about the succession. The Senecan tragedies could not appeal to the English masses, for the English playgoer demanded (and still demands) action, not narration. Yet the Senecan manner influenced English drama. It gave it the long introspective soliloquy (*cf.* Shakespeare everywhere) ; it gave it a love for the supernatural (*cf.* Hamlet's Ghost), and a taste for revenge (*cf.* the bloodthirsty plays of the Elizabethan dramatists generally), and a desire for exclamation that led to the cheap rhetoric of the Elizabethans.

A few years after the production of *Gorboduc* two typically English plays appeared, *Ralph Roister Doister* and *Gammer Gurton's Needle.* The former is the better of the two. Although classical in plot construction and in its division into five acts, it is English in its characters and story. It is an Interlude in a classical dress. The clown of the piece, Matthew Merygreek, is the old "Vice" of the Moralities in a more human form. He induces Roister Doister, a braggart and simpleton, to court the widow Christian Custance in the absence of her betrothed the merchant Gawin Goodluck. The rest is simple farce. The important feature of the play is the combination of the Morality "Vice" with the gull of Plautus.

The Stage.—When the guilds took the Miracles out of the hands of the clergy, they travelled around the country side. Their stage was a movable platform. The players dressed in the lower and played on the upper part which was open. Many guild actors became professionals or "stroller-players," and played in booths, market-places, and the courtyards of inns. The Elizabethan inn-yard had seats round the boundaries, but the common people

stood in the centre, the "pit." The stage was a platform that jutted out into the pit.

The inn-yard came to be looked upon as the best theatre, and playhouses were modelled on it. The Globe was of this pattern. The performance took place in the afternoon.

The Elizabethan audience was far from being refined. Men argued and quarrelled in the pit while the play was going on; cards and dice were played. The playgoer was out for the day and he wanted his money's worth. Hence we find Elizabethan plays full of fights and bloodshed. The stage fight was a real fight; the audience took sides, and a duel in—say—*Macbeth* sometimes developed into a general battle between the sections in the pit. The Elizabethan theatre was the equivalent of our music hall; the audience took a frank delight in horseplay, coarse wit, and blood and thunder. Shakespeare wrote for his audience.

But there was another kind of audience, the audience of the Court, the Inns of Court, and the Universities. This audience wanted something higher than music-hall "turns." We saw that *Gorboduc*, the first English tragedy, was performed at Court; the inn-yards would not have tolerated a Senecan tragedy with its lack of action. The Court drama took Seneca as a model for tragedy, Plautus or Terence for Comedy. It delighted in pageantry and music, and the Masque was very popular in exalted circles. The Masque was a kind of forerunner of grand opera; it depended upon music and pageantry. Ben Jonson wrote over forty Masques.

The University Wits.—Marlowe, Nash, Lyly, Peele, Lodge, and Greene are known as the University Wits. We shall expect to find that in their plays they show the influence of classical learning. They do; but they do not forget the Elizabethan audience and its love for the farce of the interlude and for blood. Marlowe is the greatest of them all. He is famous as the creator of the "mighty line." Blank verse in earlier drama had been a poor thing; the blank of *Gorboduc* is frankly bad. Marlowe's blank verse has majesty and great music. The other "wits" had a share in the reforming of blank verse; Peele gave it sweetness, Lyly lent it grace.

The plays of the "wits" all mirror the energy and fullness of the age. The people wanted blood and horrors; Marlowe gave them *Tamburlaine* with its score of murders, Shakespeare gave them *Hamlet*, and Kyd gave them the *Spanish Tragedy*.

Thought was not welcomed by the Elizabethans; psychology to them was of less importance than childish stage fights and trumpet blares. The childishness of the age is seen in Marlowe and the other "wits"; they mistake bombastic soliloquy for introspection. The drama of the period is often merely silly in its extravagance. Characters in Marlowe and Shakespeare rant in the manner of the villain in a modern tenth-rate melodrama. Only Marlowe and Shakespeare make them rant poetically.

Shakespeare.—We have suggested more than once in these pages that Shakespeare belongs to the class of artists who accept the ideas of their time. He is no innovator. He is quite content to take old plays and rewrite them, as Burns rewrites old songs; and he has no objection to lifting scraps of philosophy from these old plays. He is a conventional citizen, with a conventional citizen's innate snobbery; his great ambition is to be a country squire at Stratford-on-Avon. Democracy he has no sympathy with; he ridicules popular leaders like Jack Cade; he almost invariably makes his working-class characters rogues or fools; he bows the knee to pomp and rank. Like Kipling he is on the side of the Conservatives.

It has been said that Shakespeare was ahead of his times, seeing that he ridiculed popular fashions. Now there are two kinds of social critic; the one sees the foibles of society and rather likes them, the other sees the foibles and hates them intensely. W. S. Gilbert is of the former, Shaw is of the latter type. Shakespeare, like Gilbert, saw the follies of society, but he thought the follies worth having, even if it were only for the fun of laughing at them. He pokes fun at Lyly's Euphuism and Marlowe's rhetoric, but he rather fancies rhetoric and Euphuism.

As a technician he accepts the drama of the time with its extravagant make-believe. Girls disguise themselves as men, and are not discovered; bad men are paired off with virtuous maidens at the end of the fifth act, merely to give the play a happy ending; the obscenities dear to the Elizabethan pit are given with a liberal hand; clowns, the descendants of the Morality Vice, juggle with bad puns and worse innuendoes; characters do things without any rational motive (*cf.* Lear's division of his kingdom), and they believe tales that a self-respecting schoolboy would laugh to scorn (*cf.* Othello's belief in Iago's story or Claudio's belief in Hero's guilt in *Much Ado*).

If our criterion is a modern realistic dramatist like Ibsen, Shakespeare must be considered a bad dramatist; for, according to twentieth-century ideas, drama ought to be realistic—that is, a play should present no incident that is obviously divorced from real life.

Clearly Shakespeare's plays are different from Ibsen's or Strindberg's. No one in real life would break the news of Ophelia's suicide as the Queen in *Hamlet* breaks it to Laertes:

There is a willow grows aslant a brook
That shows his hoar leaves in the glassy stream, &c.

But it may not be just to say that Ibsen's plays

are better than Shakespeare's: you cannot say that claret is better than cheese. According to the realists Ibsen is the greater; according to the romancists Shakespeare is the greater.

It is as a romancist that Shakespeare must be judged; his greatness is best seen when he is compared with his contemporaries. Shakespeare's greatness lies in his poetry and music. He should be judged as a poet and musician rather than as a dramatist. He takes the plays of his predecessors and invariably he makes them beautiful works by adding music and colour. He does not invariably improve the plot; the older play *King Leir* is much more natural and simple than *King Lear* with its shallow tricks of disguise and credulity.

Shakespeare appears to have no definite criterion for life; his usual test is happiness.

Macbeth says:

Out, out, brief candle!
Life's but a walking shadow; a poor player,
That struts and frets his hour upon the stage,
And then is heard no more; it is a tale
Told by an idiot, full of sound and fury,
Signifying nothing.

Compare this with Jaques' *All the world's a stage*, and Prospero's *We are such stuff as dreams are made on, and our little life is rounded with a sleep.*

In those sayings there is no hope, no vision of a fuller life. His outlook is frankly that of a hedonist.

That Shakespeare is great no one can deny. He can draw a character brilliantly; his Falstaff is glorious. He was an excellent humorist and a passable wit. His poetry is of the highest kind. In his lyrical plays *A Midsummer Night's Dream* and *Romeo and Juliet* he is unapproachable.

The lesson we are trying to teach is this: Shakespeare is not always excellent; hero-worship too often makes students ignore his shortcomings. Our objection to him is the frankly biased one that he was neither prophet nor democrat. His consummate art we admit and appreciate.

Ben Jonson.—Ben was on the side of classical correctness in his plays as in his lyrics and prose. He hated the rhetoric and extravagance of the Romantics, and he refused to "write down" to the Globe type of audience. He calls comedy "a thing throughout pleasant and ridiculous and accommodated to the correction of manners." Oscar Wilde might have subscribed to the same definition. Shakespeare is not a comedy writer; what is called his comedy is really farce.

Ben, then, set out to tell the Londoner what he thought of him, but he did not carry out his intention well. He began to create characters with "humours" (*i.e.* eccentricities); he tried to fit character sketches from contemporary life into the classical frame of drama with its stock Roman comedy figures—the gull, the cunning servant, the braggart, the young wife and her jealous husband. As a result his characters lose reality. Ben's plays might be called Moralities with the dialogue of Plautus and Terence added.

The other dramatists.—The plays of Shakespeare's contemporaries and immediate successors belong roughly to two groups—those that followed the horrors of Kyd's *Spanish Tragedy*, and those that treated of the town manners of the day. The former type of play is generally disgusting. A good example is Marston's *Antonio and Mellida* which is full of blood and bombast. Chapman's *Bussy d'Ambois* shows similar horrors, and Webster's *Duchess of Malfi*, though a great play in the romantic manner, is full of crime and revenge, lust and hate.

The play of town manners is a better product. Dekker's *The Shoemaker's Holiday* is one of the best examples. Dekker is the J. M. Barrie of Elizabethan times; he has a strong sense of human qualities, and his women, like Barrie's, are sweet. Middleton also sticks closely to civic manners, and Jonson, Marston, and Dekker collaborate in an excellent play *Eastward Ho!*

Beaumont and Fletcher write for the court. Their plays show the decadence of the romantic play. In them we find empty bombastic speeches, which do not suit the characters who make them; sentiment posing as passion; mere coarseness pretending to be wit. The decadence of Elizabethan drama reaches its depth in Massinger, Ford, and Shirley. Massinger wrote a famous comedy, *A New Way to Pay Old Debts*, but his work as a whole shows smartness rather than genuis. Ford revels in lust and blood.

The blank verse of the drama gradually became decadent also. Shakespeare's blank verse is perfect in music; only, in his latest work, *The Tempest*, he favours the redundant syllable (see p. 117). Beaumont and Fletcher follow this license, and when Shirley and Davenant and Suckling take it up their blank verse becomes a kind of prose.

The decadence of drama has some connection with the change of power in England. Under Elizabeth England was optimistic; her sailors had sunk the Armada and founded new colonies over the Atlantic; everyone was wondering what new wonder would appear next. With the accession of James I the old spirit died. He truckled to Spain; he toyed with worthless favourites (Elizabeth's favourites were capable men). The new spirit is illustrated by the imprisonment and death of Raleigh. The optimism of a genuine patriotism gave place to the pessimism of sectarianism and partisanship. Puritanism grew apace, and in 1642 the theatres were closed. The romantic drama died out then.

Restoration Drama.—When the English drama reappears again in the age of Dryden it is a new product altogether, although Massinger's *A New Way to Pay Old Debts* foreshadows it.

Elizabethan drama was an expression of the national life: the drama of the Restoration was an expression of town life. It was an amusement for the Court and the smart set. Comedy mirrored the profligate society of the time. Anything suggesting Puritanism was burlesqued and satirised; chastity was jeered at. The playwrights had no motive beyond giving a cheap entertainment. If they condemned current morality on the ground that it was hypocritical and smug, they might be excused or praised. But they condemned morality because they were writing for the bloods who wanted license.

Restoration tragedy added English freedom of action to Spanish bombast and the extravagance of the French heroic romances of Madeleine de Scudéry. Dryden and Shadwell wrote "heroic plays." They are full of impossible feats, ranting speeches, and other absurdities. Dryden's *Conquest of Granada* is a typical "heroic play."

Dryden, Etheredge, Shadwell, Sedley, and Mrs. Behn practised comedy, but without any distinct merit. They had been trying to imitate the racy dialogue of Molière, but they never quite succeeded. Wycherley almost succeeded. His plays are not specially well constructed; he depends mostly on intrigue and coincidence. His characters are little more than types, yet such plays as *The Country Wife* and *The Plain Dealer* are good to read.

Congrève.—The name of Congrève is the greatest in Restoration comedy. Like the others he is a writer of artificial comedy with its conventional construction and its disregard for probability. His characters are stagey, but they are perfect stage folk. They talk wittily, sometimes brilliantly. But behind their talk there is no real criticism of life. Congrève's best comedies are *The Double Dealer, The Way of the World, Love for Love.*

Vanbrugh, like Congrève, is a wit. *The Confederacy,* his best play, is original in one way; it leaves the exalted lords and ladies of Restoration drama and portrays old-clothes dealers and money-lenders.

Farquhar, the third of the great artificial comedians, if less brilliant as a wit, is more modern than Congrève and Vanbrugh. His plays *The Recruiting Officer* and *The Beaux Stratagem* anticipate the eighteenth-century novel in atmosphere.

The Restoration dramatists are always being blamed, by writers who ought to know better, for their coarseness of language, yet these writers never think of condemning the innuendoes of Shakespeare which are worse because innuendo. The genuine artist believes that to appreciate the quintessence of roses one must first walk by the dung heaps. When one sees things in their true perspective one realises that coarseness of language is a minor matter. The critics who magnify the indecencies of the Restoration dramatists are on a level with the man who refuses to bathe in the sea because of the fact that people drown cats and dogs in the sea.

About the year 1700 comedy loses most of its coarseness, but it becomes a worse product than the comedy of 1660–1700. The plays of Colley Cibber and Mrs. Centlivre are poor stuff as literature. Sentimentality began to creep into comedy. This is seen in the comedies of Steele. His *Conscious Lovers,* evidently founded on Terence's *Andrea,* is classical in its stock characters and incidents. Steele's humour depends much upon his pathos for a foil; he is definitely moral in purpose, but artificial and non-dramatic.

Restoration Tragedy.—We have seen how Dryden, following Davenant, took up the heroic play with all its rant and rhetoric. Buckingham's *The Rehearsal* is an excellent burlesque of the heroic play. In *All for Love (Antony and Cleopatra)* Dryden comes nearer the tragedy of Shakespeare. Otway, the author of *Venice Preserved,* has pathos and tenderness, yet he shows the rant and staginess of the age. His verse is unmusical. He could construct a plot. Lee on the other hand was very musical in his verse, but he could not construct a plot. He has all the bombast and artificiality of the time. Southerne and Rowe are tragedians who do not rise very high. Addison's *Cato* is the last word in bad tragedy: its characters do not live, its plot is bad.

Eighteenth-century Drama.—A new fashion of writing literary plays sprang up in the eighteenth century. Thomson wrote literary plays that are forgotten. Johnson wrote a play, *Irene,* which is forgotten.

Between Steele, Cibber, and Mrs. Centlivre and Goldsmith many minor dramatists wrote farces and sentimental plays. O'Keefe's *Agreeable Surprise,* Cumberland's *The West Indian,* and Holcroft's *Road to Ruin* give a fair idea of the drama before Goldsmith and Sheridan.

Goldsmith's fame as a dramatist rests on *She Stoops to Conquer,* a fresh delightful comedy of incident and manners.

Sheridan is the author of three noted comedies. *The Rivals, The School for Scandal,* and *The Critic.* The dialogue is brilliant, the construction is good. *The School for Scandal* is not artificial like *The Rivals:* its characters live. But Sheridan, although he satirises current manners, does not go deep. He has not got away from the hollow morality of his time.

Nineteenth-century Drama.—Between Sheridan and the modern dramatists there is a time of

non-dramatic activity. The nineteenth century is the century of the novel. Any drama written was divorced from the stage. Byron wrote *Cain* and *Manfred*, Shelley wrote *The Cenci*, Tennyson wrote *Beckett*, Browning and Swinburne wrote plays. These plays are literary; they are better read than acted.

An important date in the history of English drama is 1843, when the law that gave Drury Lane and Covent Garden the monopoly of legitimate plays was abolished. Immediately theatres sprang up all over London, and competition became keen. But there were no plays of merit to put before the public.

In the early century Sheridan Knowles' tragedy *Virginius* was popular. Then in the 'forties Bulwer Lytton produced *Richelieu* and *The Lady of Lyons*, plays full of bad sentimentality and stilted expression. But the popular plays were adaptations of French farce and comedy. Then Tom Taylor came with his Frenchified machine-made plays in the 'fifties. Dion Boucicault wrote a poor if popular play *London Assurance*, and Irish melodramas, *Colleen Bawn*, *Shaughraun*, *Arrah-na-Pogue*.

During the years 1865–1870 the Bancrofts set themselves to produce something better than French farces and bad melodramas. They introduced more natural acting and staging, and greatly improved the auditorium of the Prince of Wales' Theatre. Their most important work was the production of T. W. Robertson's plays, *Caste*, *Society*, *Ours*, *School*. Robertson was no genius; he had no vision. But his plays were an antidote to the rubbish that passed for drama at the time. His follower H. J. Byron, author of *Our Boys*, a play often revived, was frankly bad as a dramatist.

English drama was not redeemed by Robertson. During the 'seventies the Bancrofts revived plays like *The School for Scandal* and introduced adaptations of Sardou's French plays. Sardou was a bad influence. His *Dora* was adapted as *Diplomacy*, and in 1913–14 this play had a great success at Wyndham's Theatre. Now *Diplomacy* is third-rate drama; it deals with a trifling incident; it pictures a conventionally jealous woman in contrast with a simpering empty girl; it is full of stupid rant. The psychology is bad, the humour feeble, and—worst of all—it depends for climax on a silly trick—the detection of a criminal by a perfume. It is a play for children.

In the 'seventies Henry Irving became popular by his performance as Mathias in *The Bells*. Irving was a fine actor, but his influence on English drama was evil. By giving the public plays like *The Bells*, *The Lyons Mail*, *Charles I*, Conan Doyle's *Waterloo*, he was popularising drama that depended on its sentimentalism or its melodrama. It led nowhere; it did not touch the intellect. It was purely emotional. Irving put the actor above the dramatist; instead of adapting himself to Shakespeare, he tried to make Shakespeare's plays adapt themselves to his own histrionic art. He introduced the elaborate staging familiar in theatres to-day (*e.g.* His Majesty's Theatre). Sumptuous scenery is a doubtful benefit to the theatre; it appeals to the eye. The beauty of Shakespeare's plays is their scenery painted in words; the Elizabethans had no scenery but the Elizabethan pit had imagination. When Don Pedro in *Much Ado* said,

> "Good morrow, masters; put your torches out:
> The wolves have prey'd; and look, the gentle day
> Dapples the drowsy East with spots of grey,"

the inn-yard audience *saw* the dawn. In a modern theatre that passage would be accompanied by flashing limelights, and in consequence the force of the lines would be lost.

During the 'eighties many of A. W. Pinero's plays were produced, but adaptations from the French still held the field—melodramas and operettas. A native melodrama grew up (*cf.* Henry Arthur Jones' *The Silver King*, 1882), and Gilbert and Sullivan's comic operas almost killed the French operetta.

Ibsen's Influence.—Pinero, Jones, Sidney Grundy, Carton, Haddon Chambers and others rescued English drama from French influence. But the chief factor in late nineteenth-century drama was the discovery of Ibsen.

In 1889, Ibsen's *The Doll's House* and *Pillars of Society* were produced in London. The Independent Theatre performed *Ghosts* in 1891, and the Press screamed forth stupid anathemas against Ibsen's alleged filth and immorality. Bernard Shaw's *Quintessence of Ibsenism* gives an excellent account of Ibsen's reception in England.

Ibsen was a dramatist with great stage technique and a great vision. He was ahead of his time. He saw the hypocrisies and the criminality of nineteenth-century morality, and he tore them aside. The greatness of Ibsen is at once realised when one compares one of his plays with—say—one of Sardou's. The play we mentioned above—*Diplomacy*—will do. In *Diplomacy* there is a story, a trifling pseudo-detective story of a bad woman's treachery. The characters are purely conventional; they say nothing of importance; they talk cheap platitudes; they do not think any more deeply than the average fashionable person in real life. The whole play is unreal, and, to an intelligent spectator very boring.

In *The Doll's House* we have a trifling incident—her forgery and financial dealings—that leads to Nora's finding her soul. The play is a study of a human soul, not a tale of a silly treachery. The interest is in Nora's gradual realisation of her cramped un-individual life with a fond

uxorious husband. The play goes straight to a great fundamental—the right of a woman to live her own life. It is a grim challenge to smug conventional morality and habit.

Pinero, Grundy, and others wrote good stage plays; but they had not the vision of Ibsen. There is a "popular" strain in their view of established things: they are not rebels.

Bernard Shaw, on the other hand, is a rebel against most established institutions. His plays are dramatically inferior to Ibsen's, but he has the Ibsen genius for seeing beyond the horizon of the man in the street. His plays sparkle with witty dialogue and humorous incident, but his wit and humour are only the sugar coating of the pill. Society, according to Shaw, is suffering from a dreadful disease—a sluggish intellect. It won't *think;* it accepts without questioning its laws, morality, religion, philosophy—everything; it is the slave of prejudice and hypocrisy. Shaw believes that Society requires a drastic remedy, and he offers it his pill. His plays are stern sermons on social and moral texts; he is one of the greatest preachers of Britain. His importance as a thinker lies in his power of suggestion; he is the best schoolmaster known since Greek civilisation. His importance in the history of English drama lies in his theory rather than his practice. His *Dramatic Essays and Opinions*, a collection of his critiques when a dramatic critic, are full of excellent comments on bad drama. He is on the side of the Naturalists, or as they are sometimes called, the Realists. He contemns sentimentalism, the exaggeration of love and its powers, jingoistic heroics and most things that a theatre-going public appreciate.

Galsworthy, the late St. John Hankin, Granville Barker all belong to the Naturalist school, and the late Stanley Houghton's *Hindle Wakes* was of the new order of drama.

Drama of Sentiment.—Outside the Realist drama there flourishes a drama that might be called the drama of sentiment. Barrie is its best exponent. Barrie's plays are full of sweetness and whimsicality; he is no stern critic of morals or customs. He has what Richard Le Gallienne describes in another context as "that sort of humour which comes of the resigned perception that the world is out of joint, and that you were not born to set it right." His romance is seen in the beautiful fantasy *Peter Pan*, a fantasy that Maeterlinck almost equals in *The Blue Bird*.

The probability is that the Naturalist play will never become popular in Britain. To-day Ibsen is played to empty benches in the Provinces, and, with the exception of an occasional Repertory production, Ibsen's plays are not staged in London. The public wants what intellectual people consider rubbish. It wants dramatisations of ranting romantic tales of adventure, farcical plays adapted from the French, and melodrama. The theatre is regarded as a playhouse, not a pulpit.

The Repertory Theatre.—Commercialism prevents the growth of a real drama. Managers look upon the "long run" play as the best; they give the public what it wants just as the average newspaper does. People still go to see a star actor rather than a play. Nevertheless there is a growing tendency to look upon the play as the thing. The Repertory Theatre movement is against the "star supported by a company." To understand the Repertory movement we must know something about the provincial theatre of the late nineteenth and early twentieth centuries. From Restoration days until the middle of the nineteenth century every large provincial town had its "stock company," which had an ever-changing repertory. The stock company was an excellent training-school for actors, and the best players drifted to the centre London. The coming of the railway ended the stock company system, and the modern touring company system took its place. By the new system all plays on tour are replicas of plays produced in London.

Now this system is unsatisfactory. The Provinces have not the same tastes as London, yet they meekly allow the London favourite plays to be thrust upon them. Moreover the touring system is generally commercial; the art-loving companies that tour with Ibsen's plays and play to a few intellectuals in the pit are heroic exceptions.

The Repertory Theatre movement came as an antidote to the commercialism of the "long run," and to the unintellectual drama. The movement, begun in London by the Independent Theatre Society and the Stage Society, was furthered by Mr. Charles Frohman and the Vedrenne-Barker management. The earliest to be founded outside London was the Irish National Theatre. The company went on tour, and gave to other towns excellent productions of plays by Synge, W. B. Yeats, and Lady Gregory. Miss Horniman founded the Manchester Repertory Theatre in 1901, and Glasgow, Liverpool, Birmingham, and Croydon followed her lead. The Repertory company gives local authors their chance; a well-known instance is that of the late Stanley Houghton, whose *Hindle Wakes*, produced by Miss Horniman in Manchester, was taken to London and there was received with enthusiasm.

Musical Plays.—The musical play hardly comes into the history of drama: it is nearer the music hall. The comic opera of Gilbert and Sullivan has gone out of fashion, and its place has been taken by the musical comedy and the revue. The charm of Gilbert and Sullivan's operas is due to the fact that Sullivan gave to Gilbert's jingling polysyllables the melody that suited them. Many praise Gilbert for his

wit, but to-day there is a growing feeling that his wit is based on a superficial view of Society. Gilbert thought Society good in the main, and he laughed tolerantly at its foibles. Shaw, on the other hand, thinks Society rotten at the core; he says extremely witty things about it, but behind his wit is a stern realisation that Society is founded on many shams and stupidities. Gilbert's forte was his genius for absurd situations; the adjective "Gilbertian" will possibly live when his wit is forgotten.

The musical comedy of the *Merry Widow* or the *Quaker Girl* type depends upon its pretty girls and their beautiful dresses, its light lyrics, and its comedians. The story is of minor importance. The revue goes a step farther and drops the story; it is simply a jumble of music-hall "turns" with the "beauty chorus" superadded. The invasion of the theatre by these diverting—and occasionally amusing—numbers has seriously hampered the growth of good drama. Managers are spending huge sums in their production; touring companies almost monopolise the provincial theatres. The musical play fosters the idea that a theatre is a place of amusement only. But the musical comedy and the revue have one great merit: they are quite frank in their aim. They do not serve up the stupid rant that passes for melodrama in many "legitimate" theatres; they do not deal in conventional characters like villains and heroes.

The music hall is not the rival of the legitimate theatre. It is a necessity. The man who can appreciate Masefield's great tragedy *Nan* or Shaw's delightful comedy *Man and Superman* can also appreciate Little Tich and Marie Lloyd. There may be competition between a musical comedy and a music hall; there is no competition between a music hall and a repertory theatre.

Anyone interested in drama must take note of the cinema vogue of the present day. As it exists the cinema is inimical to good drama. It delights in mawkishly sentimental stories of death and poverty. However, the filming of Forbes Robertson in *Hamlet* points to a higher aim. Perhaps the filming of Shakespeare will make people realise how much of his glory lies in his word-music, and colour. The cinema is excellent for farcical incident and educative pictures of bird and animal life. But it will compete with and, let it be hoped, kill the French farce, not the intellectual drama.

It is fatuous to preach against any popular movement; a nation has the plays it deserves. The present age is one of transition. People are altering their values of morality, religion, and philosophy; the worker is awakening to the fact that he slaves while rich people, through no merit of their own, live in luxury. There is a general movement to share the pleasant luxuries of the wealthy, and the result is an increased desire for light amusement. Life is not joyful to the majority of toilers, and the revue or the cinema house affords a means of forgetting life's greyness. To the poor man the cheap entertainment is a means to an end; to the Piccadilly nut it is an end in itself.

The Drama like the Press nearly always caters for the majority. The minority, hopeless of the commercial play, stays away from the theatre and reads its play at home. Most admirers of Ibsen, Strindberg, Shaw, Galsworthy, and Barker know their plays from the printed copy only.

WRITING AS A PROFESSION

Most people go through a certain stage during which they are ambitious to write novels or plays. This stage usually follows the one in which a young man is convinced that he is a born actor—this conviction usually follows a visit to one of Martin Harvey's romantic plays—and in which a young woman feels sure that all her talent is directed towards the footlights. The literary ambition seldom lasts longer than the theatrical ambition. Thus the market is never overstocked with actors and writers.

The present writer has a theory that most youths are probable geniuses; but the great majority lose self-confidence and cease from striving. After all, there is more than a little truth in the saying, "Genius is the art of taking pains." Without much labour no one ever succeeds in any art.

In the art of writing, hard study and hard thinking are essential. And the first requirement demanded of a writer is that he has something to say. The young artist does not realise this; he thinks that the art lies in the words, not in the thought. A few years ago the man that believed in words had a public; to-day, readers want a truth or a theory, and they take little interest in the way the truth is expressed. As we have pointed out in the article on Style (p. 100), the novice will persist in seeking the far-fetched word. If a young writer feels that he must write "Braid seized the iron. There was a sharp metallic click, and the rubber-core went sailing through the serene air; while the spectators, in amazed ecstasy, followed with eager eyes the rapidly moving ball," he should leave literature and take to ploughing.

Let us look into this puerile style. "There was a metallic click"; does the writer think that we expect to hear a wooden crack from a driving-iron? And why tell us that the eyes of the spectators followed the flight of the ball? The average intelligence should guess that the crowd, which follows a professional golfer, is not looking for daisies.

We shall take it for granted that the reader has got over the desire for flowery language. Does the ability to express one's thoughts

simply and directly qualify one as a writer of books ? It does, if the thoughts are worth expressing.

The Writing of Fiction.—One cannot be a great novelist until one has had much experience of life. The youth may write a great novel about his own life, if he is gifted with a wonderful power of introspection, but the only character in the work will be the portrait of the author.

Still, the young writer has a wide province that does not demand great knowledge of psychology, although it requires much imagination. This province is that of the Adventure story. No one but a very clever writer can write a book like *The Egoist,* or *The New Machiavelli;* but a tale of romantic adventure like *The Prisoner of Zenda* or *Treasure Island* can be written by a writer of imagination.

The British public does not want novels of thought; it wants tall stories with happy endings; it demands plenty of blood and villainy, or pailfuls of sloppy sentiment. The serials in the popular weeklies show what kind of stuff the non-intellectual public is reading. Most of them are childish, and unreadable if one has any taste in fiction. This type of story is purely commercial; the proprietors of those papers give the public what it wants, not what it ought to want.

The young writer who has no principles in art may become rich by writing serials and short stories for popular journals. But the young writer who sets out with the primary idea of making money is not the one we are addressing. Many a youth has said, "I can't make enough out of my art to pay for bed and breakfast. I shall stoop to write highly paid piffle; then, when I have made some money, I shall settle down to write the matter I want to write." And many a poor youth has found that after a year or two at the pot-boiling work his senses have become deadened, and he has become unable to write good work. The most dangerous thing in any art is to sell your soul for a living.

The reason why there are so many tenth-rate books on the market is that so many people are writing commercially. But there is a public for higher art; there are writers who are not out for gain alone; there are publishers who give the public what it ought to want. This is the only public worth catering for.

The Short Story.—The short story is the most difficult of all to write. In it there is no room for elaborate description, no room for verbosity. The best training for a short-story writer is the constant telling of stories to friends; if the friends object, write a story about their objecting. The telling of stories orally teaches one to select the salient features.

Consider the following story:

A professor was lecturing on astronomy to an audience in a Fife village. He told of the gradual cooling of the sun.

"Gentlemen," he said solemnly, "in seven hundred million years the sun will be a cold body like the moon. There will be no light, no heat, and consequently no life on the earth."

A farmer at the back of the hall rose to his feet.

"How—how l-long did you say that would be, Mister ?" he asked excitedly.

"Seven hundred million years, my friend."

The farmer sank into his chair with a sigh of relief.

"Thank heaven," he said huskily; "I thought you said seven million."

Compare the above simple tale with the version told by the inartistic person. Here it is:

A professor—I am not exactly sure which one, but I think it was Oliver Lodge—anyway, he was a professor of some kind. He came from Oxford, or was it Cambridge ? Anyhow, he was giving a lecture in a village in Scotland—in Fife, I think it was. I forget the name of the place; I think it was Freuchie—no, it was Kettle—no, I think it was Freuchie after all. Anyhow, he was giving a lecture on astronomy—or was it geology ? &c.

We have all listened to the man who uses the latter version, and we have all longed to slay him.

Barrie in *Tommy and Grizel* makes a writer tell a young friend to write a descriptive passage, and then cut it down by one half *leaving nothing out.* The novice will find much pleasure and profit in cutting out the irrelevant passages and words from the stories in any monthly magazine of fiction.

The short story must depend either upon its interesting plot or upon its racy dialogue. If it is a humorous tale, plot does not matter so much; the humour of W. W. Jacobs' stories lies in the dialogue, and the night-watchman's comments on men and things. On the other hand this writer's serious short stories, *e.g. The Monkey's Paw, The Well,* or *The Ghost of Jerry Bundler,* rely upon their ingenious plots. Some of Kipling's yarns have weak plots, but Kipling is one of the masters of the short story. Wells, again, another master, can write a delightful short story on the flimsiest of plots.

The young writer should keep a note-book, and should jot down any incident that might work up into a story. If he has the imagination, every incident he sees is the foundation of a yarn. He passes a telephone-box. "I wonder what would happen if I rang up some stranger ?" he says to himself. If he is an original youth he will try the experiment. If his originality does not carry him the length of boldness in deed, he will go home and imagine what might

happen in such a case. Perhaps the latter is the better course; the average telephone subscriber has little of the artist in his nature, and would merely look upon the youth as an idiot or a very impertinent fellow.

This telephone suggestion reminds us of the contest between Romance and Realism. A realistic story written round this incident would contain the words, "I am afraid you have made a mistake; you must have got the wrong number." A romantic story would make a lady come to the 'phone and carry on a witty conversation, and ultimately marry the original youth who rang her up.

Beware of introducing stock characters. The black-moustached villain, the fair-haired hero, the insipid wronged heroine are all very well in a cheap melodrama, but in good short stories they are out of place.

The writer of short stories soon discovers that he cannot place his work unless he sacrifices his art to the popular taste. The whole atmosphere of a story may demand that a character dies at the end, but the writer, if he cares more for money than for art, will give the public its desired happy ending.

Dialogue.—Young writers generally make the mistake of putting literary language into the mouths of their characters. Instead of making Mr. Smith say, "I'm going to the club. If I can manage it, I shall be home about eleven," they make him say, "I am going to pay a visit to my club. If circumstances permit, I shall return to my domicile at the hour of eleven P.M."

We must remember that the speech must suit the speaker. If one of your characters is a pompous gentleman who likes stilted language, by all means make him use words like "domicile."

The writer of fiction must always ask himself the question, "Would this character say this?"

The novice has great difficulty in finding variants for "he said." It is much better to use the simple "he said" again and again than to cover a page with phrases like "he asseverated," "he ventured," "he remarked." Each of these has a specialised meaning; *e.g.* "asseverated" means "declared emphatically." The specialised meaning shows the danger of using a book of synonyms. In any book of synonyms the words *disengaged, generous, candid,* are given as synonyms for *free.* Imagine a novice using "A Candid Library" for "A Free Library." The dictionary of synonyms is a useful friend to the educated man, but to the beginner it is a dangerous companion.

Never use expressions like "he cried," "he exclaimed," "he groaned," &c., unless you mean them. On the other hand, beware of using weak expressions at the wrong times. Youths have been known to write, "'Hands up, or I fire!' he remarked," or "'Farewell, dearest,' he suggested."

The descriptive adverb is a difficult article to manage. Note the following:

He said softly, he said quickly, she answered impatiently, he shouted angrily, she asked firmly, he demanded sternly, he declared loudly, she said smilingly, Mr. Thoms replied nervously, he added hastily, she continued pleasantly.

These adverbs are used correctly. But the following are incorrectly used:

He shouted quietly, she asseverated doubtfully, he cried softly. But why multiply instances? Common sense will prevent a writer's using adverbs stupidly.

Dialogue should, if possible, run without tags like "he said," but there should never be any doubt about who is speaking. There is no doubt in the following passage:

"I am afraid," said he, "that you are Victorian in your ideas."

"Why do you say that?" she asked.

"Well, you don't believe in freedom for women."

"Oh yes I do—freedom of a kind."

Charles smiled.

"Are you a suffragette?"

"Theoretically, yes."

"And practically?"

"I don't burn mansions, if that's what you mean."

If more than two characters are present this method cannot be used.

If dialogue is used the writer should invent his own spelling; the idea is to convey the correct sound. For instance take the London pronunciation of *about.* In a dialect story it might be written "abaht," "abawht," or even "abart." In Scots the word is "aboot."

Writers of dialect should remember that they are using a dialect that is Greek to most people. If an East Coast Scot wrote this sentence, "Far ur ye gaein'? Ye hev' yer neeps to clat, an' ye man feenish the nicht." Few Englishmen would guess that the sentence meant, "Where are you going? You have your turnips to hoe, and you must finish to-night."

Barrie's dialect is not quite the dialect of Thrums (Kirriemuir); it is the Kirriemuir dialect rendered intelligible to Southerners.

The Long Novel.—As we said above, the novel is the province of the experienced writer. The great merit of the novel is its freedom; it has no conventional form; it does not necessarily require a strong plot; it may be a sermon in dialogue, or a tract on Socialism. The one thing demanded of it is that its characters should live. In an adventure story character is of subsidiary importance; if the hero comes unscathed through all dangers and the heroine is rescued at the end, we are quite pleased; we do not ask whether they have been puppets or real live people. The better class of adventure

story, however, takes care to make the characters live persons.

It is almost useless to sit down saying, "Now, I am going to make this man Watson a silly sort of person. I must make him a foil to the brilliant Johnson." If you say that, you will possibly find that Watson refuses to be a stupid person; he will persist in saying witty things to Johnson, and you will discover with alarm that Johnson is the stupid man who never has an answer ready. It is difficult to understand how novelists make characters that are mere "sticks" . . . until you try to write a novel. The natural thing for a creation to do is to grow, to evolve. The great danger is that it may grow in the wrong direction. The novel affords space for a character to grow; in the space of a hundred thousand words there is room for a man to grow from childhood to old age, to progress from Christianity to Atheism, from conservatism to anarchy.

The first step in writing a novel is to fix on an idea—it need not be a definite plot; if you make a hard and fast plot you will find, if you are really clever, that your characters will not fit into the framework. Shakespeare wrote some bad plays because he tried to make real characters fit into a conventional framework. Perhaps the best way is to form a provisional plot. Make up your mind that Algernon is to marry Margaret in the last chapter, but if you find that Margaret is in love with Reginald (and, remember, you have no control over Margaret), Margaret must marry Reginald. The novelist holds the reins in the first chapter; after that, the characters drive the chariot.

Novel-writing cannot be taught; but young writers of imagination and insight into character may be warned against certain faults that will mar their work.

It is in novels that we find the stilted style at its worst. The novelists refuse to be simple, and there are modern novels that compel a well-educated person to keep a dictionary close by. If a writer uses the word "pandiculate" instead of "yawn," a sensitive man will lay down the book at once.

Again, the use of hackneyed terms is common in many novels. Perhaps the most banal is the use of the word "individual." This word should never be used as a synonym for "person." The Victorian novelists made this a pet word; it came to have a semi-humorous application. When a nineteenth-century novelist wrote "Then entered a red-nosed individual;" his readers were supposed to laugh. Its pseudo-facetious meaning killed "individual" as a good substitute for "person." The best writers nowadays use the noun "individual" to indicate a person as opposed to a crowd. We can say that a crowd is composed of so many individuals.

Dickens and Thackeray are not the best guides for a young novelist. He will do better to study the technique of Wells, Bennett, and Locke. But much reading of novels is not the best training for a novelist. The best training is the writing of letters.

Letters.—The young writer should find a patient correspondent, and fill sheets with matter. This is the best manner of finding a style and, at the same time, a soul. There are two kinds of letter. The ordinary one runs in this fashion:

MY DEAR DOROTHY,—I had your note this morning and was glad to hear that your cold had gone.

I went to the Lyceum last night with Dick, and saw Tree in *The Darling of the Gods*. He was ripping.

I am thinking seriously of coming to London this Xmas. Father says that he can't afford the expense, but I think I shall manage to persuade him, &c. &c.

The above is a sample of the chatty "news" letter, but it is not the kind of letter that a young writer should compose. Here is a sample of the other kind, the only kind worth calling literature:

DOROTHY, DEAR FRIEND,—A phrase in your last letter set me thinking. You remarked, "Ferguson is a rough-looking man, but he has one great merit—he is chivalrous."

Now, I wonder what your ideas of chivalry are. Are you one of the many women who think chivalry is a matter of bowing and holding doors open? I hope not. Personally, I don't believe in chivalry, for chivalry is dead. Men rise to offer girls their seats in trains and tubes, and these men go off to boss typists and waitresses who are paid wages that are a disgrace to our civilisation. If chivalry were alive, would men allow women to work in East London for sixteen hours a day making shirts at three-halfpence an hour?

I am tired of all this cant about chivalry; it is all a sham . . . and the women do their best to keep up the sham. They cry for freedom, for votes, but they want to keep all the old cheap privileges. They are for the most part content with a lip service. They judge a man by the little unessential things, the things that shouldn't count in life. I despair of what is called Women's Freedom sometimes. I see so many women who love to be on a pedestal. I don't blame them so much as I blame the men. The knights of old placed woman on her pedestal; they hedged her round with a high wall to keep the ugly things of life from her eyes. And to-day the men that wear spats are still carrying bricks to that wall. Why should men presume to dictate to women about what they shall see? &c. &c.

This letter is the only letter that counts as an education. It educates the writer; it makes him or her marshal his or her thoughts. A good letter tells what one thinks, not what one does. It may be frankly egotistical; a good correspondence is the best training in introspection in the world. And without the power of introspection no one can write well. Write to your friends about the books you have been reading, about the things you have thought, the theories you have formed. Do not be afraid to preach; every one with any convictions preaches. Your theories may not be the accepted theories of your friends; if they are you had better give up all thoughts of writing anything worth reading.

COURSE OF READING

English Language.

The student should commence with a book on the history of words, rather than one on the history of language generally. Perhaps the most interesting book on words is *Words and Their Ways in English Speech*, by Greenough and Kittredge. Ernest Weekley's *The Romance of Words* and *The Romance of Names* are two recent books of interest.

There are three excellent books on the history of language. They are Jespersen's *Growth and Structure of the English Language*, Toller's *Outlines of the History of the English Language*, Emerson's *History of the English Language*. Jespersen is specially good on the Romance influence, and Toller is very exhaustive on the Latin influence.

Lounsbury's *Outlines of the History of the English Language* is very good also.

The Making of English, by Henry Bradley, is generally looked upon as the standard work on the subject. Wyld's *The Historical Study of the Mother Tongue* is full of suggestion. Its object is to create an attitude towards, not to give a history of the English language.

The above books will give any student an exhaustive knowledge of English philology. He who wants to study more deeply in philology will find a sufficient library ready to his hand. Sweet's *History of Language* is a good introduction. Max Müller's *Science of Language* is well known, and *History of Language* (an adaptation of Paul's *Principles of the History of Language*), by Strong, Logeman, & Wheeler, is an important work. Skeat has a good modern book called *Philology*, and Jespersen's *Progress in Language with Special Reference to English*, makes excellent reading.

Among older books are Whitney's *Life and Growth of Language* and his *Language and the Study of Language*; Sayce's *Introduction to the Study of Languages*.

Needless to say, the student should study modern works. Philology has moved rapidly in the past few years.

Old English.—Undoubtedly the best book on Old English Grammar is Cook's translation of Sievers' *English Grammar*. But we warn the reader who idly takes it up. It is literally crammed with information, and to the unenthusiastic student (and very few students like Old English) it is Greek—only ten times more difficult.

The usual way to get up Old English is to sit down with a book like Sweet's *Anglo-Saxon Reader* or Morris and Skeat's *Specimens of Early English*, Part I, on one's knee, and an Old English dictionary at one's feet.

Lazy (and incidentally sensible) students use "cribs." Personally we believe in keys. Read the *Beowulf* through with a good translation, and you get up a fair vocabulary. But so many translations of the *Beowulf* are bad that the experiment is often harmful. The translations of Child, Clark Hall, and Garnet are all "safe." A good text to use is Wyatt's *Beowulf*.

An excellent book on Old English is Cook's *First Book in Old English*; we strongly recommend all students to get a copy.

Good Old English dictionaries are those of Sweet, Toller, Clark Hall.

Middle English.—Most of the books already mentioned cover the Middle English Period. Sweet has a *First Middle English Primer*, and a *Second Middle English Primer*. Morris and Skeat's *Specimens of Early English*, Part II, is a familiar text-book in universities.

English Grammar.—It is useless to mention all the grammars found in schools. Everyone knows names like Meiklejohn, Nesfield, Mason. It should be remembered that grammar books soon go out of date.

The student will do well to read books on syntax and the correct use of words. One of the most interesting books of this kind is *The King's English*, issued by the Oxford Press. The attitude of this book to English writing is analogous with that of the public school boy to social ethics. As the public school boy has definite ideas of what is good and what is bad form, so has *The King's English* a definite idea of what is and what is not "correct" English. It appears to ignore the fact that the people make the language. It objects to the use of *mutual* in the phrase *mutual friend*; but nearly everyone says *mutual friend*. The present writer once gave offence to a nice old lady: he had been reading *The King's English*, and talked of the curate as "our common friend."

Mutual friend is fixed in the language, and all the "correctness" in the world will not drive it out. If *The King's English* cries "But *mutual* is used here with a wrong meaning," we reply, "Well, *manufactured* goods are goods *not made by hand*."

The King's English is a book that is well

worth reading. Our only objection to it is that it is liberal-conservative in its attitude to matters like split infinitives, the *shall* and *will* difficulty, the use of certain words. But in its treatment of grammar (*i.e.* the best order of speech of the best people) it is excellent. There is an abridged edition for school use.

Books like Hodgson's *Errors in the Use of English*, Nesfield's *Manual of English Grammar and Composition* (with key), and Miss Masson's *Use and Abuse of English* (containing a good section on Scotticisms), should also be read critically.

Any good dictionary will give the pronunciation of words. But even good dictionaries sometimes fall victims to pedantry. *Collins' Graphic English Dictionary*, for instance, a very good student's dictionary, gives the pronunciation of *phthisical* as *tiz'-i-kal*. But every doctor pronounces it *thigh'-si-cal*. If doctors don't know the medical language, who knows it? The only criterion is the usage of the men in the profession. If motorists decide to pronounce the word *garage* as *garr'-idge*, *garr'-idge* it will be.

Students should beware of degenerating into walking dictionaries. In other words, they should be ready to renounce a dictionary pronunciation if necessary.

There are three good books on phonetics—Sweet's *Primer of Phonetics*, Jones's *The Pronunciation of English: Phonetics and Phonetic Transcriptions*, and Williams' *Phonetics for Scottish Students*.

English Literature.

There are many books that aspire to giving a full account of English literature from the origins. The standard work is undoubtedly *The Cambridge History of English Literature*, but this huge work is beyond the means of the average student. It can be seen in most libraries.

Chambers's *Cyclopedia of English Literature* is very good. It can be had for about 7*s.* 6*d.* second-hand.

Of shorter "histories" Saintsbury's *Short History of English Literature* is perhaps the most exhaustive. It is a mine of information. But it cannot be denied that it tires the reader. It isn't that it lacks enthusiasm: what it does lack is philosophy. It is catholic and conservative; it is the work of a man with a definite point of view. Saintsbury has no sympathy with "modernism." But, according to many, his chief shortcoming is his devotion to "form." He looks on Blake as a great metrist; he dismisses Blake's social philosophy as the imaginings of a madman. So, in another book, he dwells on Nietzsche's prose style, not his teaching. But no man alive has a greater *knowledge* than Saintsbury. His books always instruct, and they instruct much by negation. His works are very important because he has a definit point of view.

Andrew Lang's *History of English Literatur* has more enthusiasm than critical value, but i is obviously a first writing without adequate revision.

Morley's *First Sketch of English Literature* is a popular text-book at universities.

A very good handbook is Stopford Brooke's *Primer of English Language* (1*s.*), which the student can read in a few hours. It is a very suggestive little book. The same author's *English Literature*, A.D. 670–1832, is also a good book.

Another exhaustive small book is Compton-Rickett's *A History of English Literature* (People's Books, 6*d.*). It is quite up-to-date, and its criticisms are original.

Good school text-books are Wyatt and Low's *Intermediate Text-Book of English Literature*, Thompson's *Student's History of English Literature*, Pantcoast's *Introduction to English Literature*.

The student should beware of books that pay too much attention to the lives of authors. The name of Milton's second wife is of no importance. Some of our modern "literary" weeklies and monthlies seem unable to distinguish between literature and gossip. They publish tit-bits about the number of pipes Carlyle smoked, or the quantity of snuff Ben Jonson used (if he used snuff); and the plumber with literary leanings thinks he is reading about literature.

Early Period.—Many histories of English literature are weak in their treatment of Old English, but fortunately we have some good works on the early period. Stopford Brooke's *History of Early English Literature* is a very good book. Jusserand's *Literary History of the English People* is especially good on Langland and Chaucer. Ten Brink's *Early English Literature* is an acknowledged classic.

Books on Chaucer are numerous. We have Coulton's *Chaucer and his England*, Ward's *Chaucer* in the English Men of Letters Series, Hales' *The Age of Chaucer*, Pollard's *Chaucer*, and the recent translation of Legouis' *Chaucer*—supposed by some scholars to be the best yet seen.

There are some excellent books on mediæval literature generally. Ker's *The Dark Ages*, Saintsbury's *Flourishing of Romance and Rise of Allegory*, Ker's *Epic and Romance*, and Rhys's *Arthurian Legend* are all very readable and suggestive.

The Renaissance.—Two arresting modern works are Stephenson's *The Elizabethan People* and Sheavyn's *The Literary Profession in the Elizabethan Age*. Jusserand's *Literary History of the English People* (vols. ii. and iii.) covers this period, as does also Saintsbury's *Elizabethan Literature*.

The Age of Dryden Onwards.—Garnett's *Age of Dryden*, and Dennis's *Age of Pope* are well worth reading.

For Nineteenth-Century Literature the student should read Herford's *Age of Wordsworth* and Walker's *Age of Tennyson.* Saintsbury's *Nineteenth-Century Literature* is full.

Mair's shilling *English Literature, Modern,* is a very suggestive and sound book dealing with the period from the Renaissance to Mr. Yeats.

Saintsbury and Raleigh each have a book entitled *The English Novel.*

Poetry.—The standard history of English poetry is Coupthope's large work, the volumes of which are usually consulted in free libraries. It is full of theories that one will challenge. Because of this it is excellent, and part of its excellence lies in the fact that there are so many theories that one challenges . . . and accepts.

Every student must read Hazlitt's delightful *Essays on Poetry,* Wordsworth's *Prefaces,* and Coleridge's reply to Wordsworth's theories on poetry. The main points of these works are given by Saintsbury in his *Loci Critici,* a book that gives excerpts from all the important critics from Aristotle to Pater.

The Channels of English Literature series has some very good books in poetry. They are *English Epic and Heroic Poetry,* by MacNeile Dixon; *English Lyric Poetry,* by Rhys; *English Elegiac, Didactic, and Religious Poetry,* by Beeching and Bayne; *English Dramatic Poetry,* by Schelling; *English Satiric and Humorous Literature,* by Smeaton.

Greg's *Pastoral Poetry* is a very good book; it is specially interesting on the Masque. A work worth reading is Stopford Brooke's *Studies in Poetry.* And Stedman's *Victorian Poetry* is a well-known book.

There are a few good books on the Ballad. One of the most charming is Gummere's *The Popular Ballad.* Henderson's *The Ballad in Literature,* and Hart's *Ballad and Epic* are suggestive. And we must not forget Andrew Lang's treatment of the Ballad in the *Encyclopœdia Britannica.*

It is impossible to give the works dealing with all the poets, but a few must be mentioned.

Books on Shakespeare are very numerous. Everyone knows the books by Dowden (*Shakespeare: his Mind and Art*), Raleigh, Sidney, Lee, and Hudson. There are books by Herford, Swinburne, Brandes, Masefield, and Darrell Figgis. The heretical view is found in Shaw's *Dramatic Essays and Opinions,* and in a few of his prefaces to plays, and in *Tolstoy on Shakespeare,* a sixpenny book, including *Shakespeare and the Working Classes,* by Crosby, *Mr. G. Bernard Shaw on Shakespeare,* and *The Press against Shakespeare.*

The student should read Boas' *Shakespeare's England,* and a book of the same title by Lee; also *Shakespeare's Predecessors in the English Drama,* by Symonds.

There are good books on Milton by Professor Raleigh, Stopford Brooke, Hudson, Mark Pattison, and Verity.

Blake, after long neglect, has now got a small library to himself. There are six "lives" of importance—by Ellis, Symons, Swinburne, W. B. Yeats, Hugh de Selincourt, Chesterton. Symons deals with the "English Nietzsche" aspect of Blake, and Chesterton deals with his alleged madness and his art.

Dowden and Symonds on Shelley cannot be ignored, and admirers of Tennyson should read the works by Ker, Watson, Benson, and Jones.

Chesterton is always delightfully suggestive in his "lives." He has splendid works on Dickens, on Thackeray, and on Browning. Swinburne also has a book on Dickens.

Readers interested in modern literature will find the works of Irving and of Palmer on the theatre very readable. William Archer is excellent in his *Play-making, a Manual for Craftsmen,* and Titterton's *From Theatre to Music Hall* is good. The "lives" in the English Men of Letters Series are all "safe," but few of them are startling in their views.

The fullest bibliography in existence will be found in the *Cambridge History of English Literature.* If a student is specially interested in an author, he will easily discover what books deal with his works by asking any bookseller to lend him the Publishers' Catalogue.

A. S. Neill, M.A.

GREEK

THE UTILITY OF GREEK AND LATIN

There was a time, not more than two generations ago, when the education of every boy included some sort of grounding in Latin and Greek. Not only so, but every man who laid claim to any degree of culture possessed a scholarly knowledge of these languages, and was familiar with their literature. No speech in Parliament was considered complete unless pointed with a quotation from the Classics, Horace for preference—a different state of things from that obtaining at present, when one member has been known publicly to rebuke another for quoting in a language unintelligible to an appreciable portion of the House. The main contributing cause to this has been the rapid progress of applied science, and the consequent necessity for advanced technical training in very many occupations. Another factor that has told against the study of Latin and Greek is the increasing cosmopolitanism of commerce. Trade with foreign countries increases day by day, and with it grows the need for knowledge of the various European languages, to make room for which something of less value in education must give way.

Thus it is that more and more Classics have been displaced from our schools by other subjects. We have been told that, in an age of bustle and grinding competition, no man who wishes to succeed in business or to become expert at his trade can afford to give precious hours to the study of a dead language, or to spend in acquiring a dry-as-dust and empty erudition the time in which he might be equipping himself to face the great struggle for existence.

So strong is this feeling in some quarters, to such an extent is classical learning regarded as a backwater, leading nowhere on the stream of life, that a few words seem desirable here, not as an apology for Latin and Greek, but to point out the real benefits that may be obtained from their study, so that anyone setting out to acquaint himself with them may feel, not that he is, at the best, following a leisure-hour fancy, but rather that he is undertaking what from many points of view will be for his benefit.

Taking the severely practical standpoint in the first place, the Classics are of great utility when the study of languages other than our own is in question. The Roman Empire extended for several centuries over these islands, France, Spain, and the Balkans; the Roman soldiers who campaigned there, the merchants who traded, and the colonists who settled, all brought their language with them, with the result that, although they themselves in time disappeared, they left an indelible impression on the language of the country in which they had sojourned.

Taking our own language first, the influence of Latin on English has not been so pronounced as in the case, for example, of French or Spanish. For this the successive conquests by Saxon and Dane must account, though the later Norman conquest brought the influence of Latin indirectly to bear through the medium of Norman-French. At any rate this is certain, that a large proportion of words in common use in English are derived from Latin, and it follows naturally that one who knows Latin is better equipped to understand his own language and to appreciate subtle distinctions of meaning. In scientific terminology Latin reigns supreme. The doctor, the surgeon, the chemist, the botanist, the zoologist, and the lawyer all find the technical terms of their profession in the storehouse of Latin. Nor is the process at an end. New words of a technical nature are continually being formed, if not from Latin words, at any rate on Latin models. An instance of this is seen in the terminology of the art of flying. From *avis*, a bird, are formed *aviation* and *aviator*, words which are new to either language, but are constructed on the analogy of derived nouns in Latin.

It is thus clear that a knowledge of Latin enables the possessor to understand his own language scientifically, and gives him a command over it that is otherwise to be attained with difficulty.

In the case of French, Spanish, and Italian, a knowledge of Latin is of still more utility. French is based on Latin, so that one who has learned the latter can readily appreciate the structure of the former, and has, as it were, a start in the race for efficiency. While Spanish and Italian have developed so truly from Latin that a working acquaintance with Latin enables one to understand the

with little trouble, and to learn them with ease.

A knowledge of Latin and Greek, moreover, has a value other than mere utility. The masters of classical literature have been for centuries, and still are, the source whence writers of all modern languages seek very largely their models. The Renaissance took life from Latin and Greek literature, and, quite apart from the intrinsic value of the literatures of Greece and Rome, it is hard without some knowledge of them to appreciate, and often to understand, some of the most treasured writers of later times.

Add to all this that classical literature includes poets and prose writers surpassed only by few, so that not to have read them is to have missed one of the highest possible literary pleasures, and add further that they can only be properly appreciated when read in the original; the case for the Classics then stands sufficiently strong to warrant our entering on their study without further preface.

The Greek Alphabet

Capital.	*Small.*	*Name.*	*English equivalent.*
Α	α	alpha	a
Β	β	beta	b
Γ	γ	gamma	g, as in *game*

N.B.—When γ is followed by γ, κ, χ, or ξ in the same word, it is pronounced as *n*.

Δ		delta	
Ε		epsīlon	e, as in *bed*
Ζ		zeta	dz
Η		eta	e, as in *feet*
Θ		theta	th, as in *thin*
Ι	ι	iota	i, as in *it*
Κ	κ	kappa	k
Λ	λ	lambda	l
Μ	μ	mu	m
Ν	ν	nu	n
Ξ	ξ	xi	x
Ο	ο	omīcron	o, as in *pot*
Π	π	pī	p
Ρ	ρ	rho	r
Σ	σ, ς	sigma	s

N.B.—The form ς is always used at the end of a word, and nowhere else.

Τ	τ	tau	t
Υ	υ	upsīlon	ü
Φ	φ	phi	ph
Χ	χ	chi	kh
Ψ	ψ	psi	ps
Ω	ω	ōmega	o, as in *oh*

Note.—There also was used in early Attic Greek a letter *F* called digamma and pronounced as *w* or *v*.

Diphthongs.—The proper diphthongs are:

αι	pronounced	as	eye
αυ	,,	,,	aw
ει	,,	,,	eye
ευ	,,	,,	ewe
οι	,,	,,	oy
ου	,,	,,	ow
ηυ	,,	,,	e-ewe
υι	,,	,,	wy

There are also the so-called improper diphthongs, ᾳ, ῃ, ῳ, in which the iota which goes to form them is written underneath and is not sounded.

Breathings.—In the absence of a letter like the English *h*, the Greeks used to represent the aspirate by the sign ʽ. This only occurs at the beginning of words, and is written over the vowel to which it belongs. In the case of a diphthong it appears over the second of the two vowels. Whenever the vowel is not aspirated, the sign ʼ is used instead.

Note.—Alone of all the consonants, ρ at the beginning of a word always has the ʽ sign above it.

Note that in order to avoid pronouncing two successive vowels Attic Greek makes use of the following various means:

1. *Elision*—the dropping out, or eliding, of a short vowel at the end of a word before a vowel beginning the next word, its loss being marked by an apostrophe —*e.g.* ἀπὸ ἡλίου becomes ἀφ' ἡλίου.
2. *Crasis*—the running of a word which ends in a vowel or diphthong into the vowel or diphthong which begins a following word—*e.g.* τὰ αὐτα becomes ταὖτα; καὶ ἀγαθός becomes κἀγαθός.
3. *Contraction.*—When one vowel follows another in the same word it generally merges with it into a single long vowel or diphthong — *e.g.* φιλέω becomes φιλῶ; τιμάεις becomes τιμᾷς.
4. *Attachable ν.*—At the end of words terminating in -σι, and of verbs in the Third Person ending in -ε, ν is added, often before a consonant, always before a vowel.

Inflexion

In English, when we wish to express the relation of one word to another, we do so by means of prepositions. For instance, if it is desired to associate the two words *King* and *England*, we use the preposition *of* to show the relation in which one stands to the other, and say the *King of England*.

In a language such as Greek, which makes use of inflexion, the relationship of words towards their context is expressed by means of

varying forms of the words themselves with or without the further aid of prepositions.

Inflexion of this nature is seen to a slight extent in English in the case of verbs—*e.g.* *I gave the book* indicates Past time, while *I give the book* indicates Present time; the essential part of the word *give* is retained in each case, but its form is changed to express a different shade of meaning.

In Greek, Nouns, Pronouns, Adjectives, and Verbs are subject to inflexion, which is of two kinds:

1. *Declension* of Nouns, Pronouns, and Adjectives.
2. *Conjugation* of verbs.

Declension

Declension comprises differences according to Gender, Number, and Case.

(a) *Gender.*—In Greek there are three genders: *Masculine*, *Feminine*, and *Neuter*.

(b) *Number.*—There are three numbers in Greek, viz. *Singular*, *Dual*, and *Plural*.

The *Dual* number is used when two persons or things are represented as doing something or as the object of an action.

(c) *Case.*—It is the case that marks the relation which a noun, pronoun, or adjective bears to the words that surround it. Thus in the expression, "There comes a tide in the affairs of man," the relation of the word *man* to the word *affairs* is made clear by the possessory preposition *of*. In Greek that relation is expressed by a variation in the form of the word for *man*, which shows clearly that *man* is a possessive and depends on one of the contiguous words.

There are five cases in Greek, which are generally listed in the following order:

Nominative—the case of the subject.

Vocative—the case used in speaking to a person.

Accusative—the case of the direct object of a verb, *e.g.* "To wake to ecstasy the living lyre"—*the living lyre* is accusative.

Genitive—the case of
  i. Possession;
  ii. Motion from.

Dative—the case of advantage.

There were also originally an Ablative, a Locative, and an Instrumental case, of which the functions of the Locative are discharged by the Dative and of the Instrumental and Ablative by the Genitive.

The cases are distinguished by different endings, which again are divided into three different series, known as the three declen-

First Declension.—In this declension there are five types:

θύρα (fem.), a door.

	Sing.		Dual.	Plur.
Nom.	θύρα	a door	θύρα	θύραι
Voc.	θύρα	o door		θύραι
Acc.	θύραν	door		θύρας
Gen.	θύρας	of the door	θύραιν	θυρῶν
Dat.	θύρᾳ	to the door		θύραις

N.B.—This type of ending in -ᾱ is only found after ρ or ι.

Μοῦσα (fem.), Muse.

	Sing.	Dual.	Plur.
N.V.	Μοῦσα	Μούσᾱ	Μοῦσαι
Acc.	Μοῦσαν		Μούσᾱς
Gen.	Μούσης	Μούσαιν	Μουσῶν
Dat.	Μούσῃ		Μούσαις

The commonest type is:

λήθη (fem.), forgetfulness.

	Sing.	Dual.	Plur.
N. V.	λήθη	λήθα	λῆθαι
Acc.	λήθην		λήθας
Gen.	λήθης	λήθαιν	ληθῶν
Dat.	λήθῃ		λήθαις

Nouns of the above types are always feminine. Masculine nouns in this declension are always of the third or fourth type:

νεᾱνίας (masc.), a young man.

	Sing.	Dual.	Plur.
Nom.	νεανίας	νεανία	νεανίαι
Voc.	νεανία		νεανίαι
Acc.	νεανίαν		νεανίας
Gen.	νεανίου	νεανίαιν	νεανιῶν
Dat.	νεανίᾳ		νεανίαις

ναύτης (masc.), a sailor.

	Sing.	Dual.	Plur.
Nom.	ναύτης	ναύτα	ναῦται
Voc.	ναῦτα		ναῦται
Acc.	ναύτην		ναύτας
Gen.	ναύτου	ναύταιν	ναυτῶν
Dat.	ναύτῃ		ναύταις

Note.—In the First Declension
  i. All nouns of which the nominative singular ends in -η or -α are feminine.
  ii. All nouns in -ας or -ης are masculine.
  iii. The genitive singular of masculine nouns ends in -ου.

Second Declension.—This declension has five types:

Masculine:

λόγος, word.

	Sing.	Dual.	Plur.
Nom.	λόγος	λόγω	λόγοι
Voc.	λόγε		λόγοι
Acc.	λόγον		λόγους
Gen.	λόγου	λόγοιν	λόγων
Dat.	λόγῳ		λόγοις

Neuter :

ἔργον, work.

	Sing.	Dual.	Plur.
N.V.A.	ἔργον	ἔργω	ἔργα
Gen.	ἔργου	ἔργοιν	ἔργων
Dat.	ἔργῳ		ἔργοις

Many nouns ending in -εος, -οος, -εον, and -οον fall under the influence of the Attic dislike for two consecutive vowels, and are contracted, as in the two types that follow:

νοῦς (masc.), mind (νόος).

	Sing.	Dual.	Plur.
Nom.	νοῦς (νόος)	νῶ (νόω)	νοῖ (νόοι)
Voc.	νοῦ (νόε)		νοῖ (νόοι)
Acc.	νοῦν (νόον)		νοῦς (νόους)
Gen.	νοῦ (νόου)	νοῖν (νόοιν)	νῶν (νόων)
Dat.	νῷ (νόῳ)		νοῖς (νόοις)

ὀστοῦν (neut.), bone (ὀστέον).

	Sing.	Dual.	Plur.
N.V.A.	ὀστοῦν (ὀστέον)	ὀστῶ (ὀστέω)	ὀστᾶ (ὀστέα)
Gen.	ὀστοῦ (ὀστέου)	ὀστοῖν (ὀστέοιν)	ὀστῶν (ὀστέων)
Dat.	ὀστῷ (ὀστέῳ)		ὀστοῖς (ὀστέοις)

Note.—All nouns in -ον are *neuter* in this declension, and most in -ος are masculine, except

1. Names of trees, countries, towns, and islands, which are feminine.
2. Twenty-one other nouns ending in -ος are feminine; viz. ψῆφος, pebble; ψάμμος, sand; πλίνθος, brick; σπόδος, ashes; κέλευθος, path; ἀτραπός, path; ὁδός, road; ληνός, vat; σορός, coffin; γνάθος, jaw; νόσος, disease; βίβλος, book; ῥάβδος, staff; τάφρος, ditch; δρόσος, dew; δοκός, beam; ἤπειρος, continent; βάσανος, touch-stone; νῆσος, island; κάμινος, oven; γέρανος, crane.

There is a fifth type in which -ω appears in the case-endings instead of -ο. Masculines in -ως and neuters in -ων are found according to it. One will show how all are declined.

λεώς (masc.), people.

	Sing.	Dual.	Plur.
N.V.	λεώς	λεώ	λεῴ
Acc.	λεών		λεώς
Gen.	λεώ	λεῴν	λεών
Dat.	λεῴ		λεῴς

Third Declension.—The Third Declension comprises many different types. The general scheme of declension is, however, the same throughout, and the following table of case-endings will be found always to be applicable, apparent variations being explained by rules of sound which will be commented on as they arise.

	Sing. Masc. and Fem.	Sing. Neut.	Dual. Masc., Fem. and Neut.	Plur. Masc. and Fem.	Plur. Neut.
N.V.	-ς	none	-ε	-ες	-α
Acc.	-α or -ν	none		-ας	-α
Gen.	-ος	-ος	-οιν	-ων	-ων
Dat.	-ι	-ι		-σι(ν)	-σι(ν)

Thus, given the stem of a word, it is always easy, by means of the appropriate ending, to put it into any particular case.

By the stem of a noun is meant that part of it on which the cases are built up. A noun consists:

1. Of a root which conveys the basic notion of the word;
2. Added to the root, as a rule, are one or more suffixes which so far modify the meaning of the root as to determine with which of the parts of speech the word shall be classed.

1 and 2 combine to form the stem.

3. The case-ending.

The stem of a noun of the Third Declension can generally be discovered by discarding the -ος of the gen. sing.: what is then left is the stem. The simplest type in this declension is that in which the stem ends in -β, -γ, -δ, -κ, -τ, -χ, or -λ. In all these cases:

i. The nom. sing., if masc. or fem., retains the case-ending -ς.

ii. The acc. sing. ends in -α.

iii. In the nom. sing. and dat. plur., by the laws of euphony, β and φ become π before σ; γ and χ become κ; τ, δ, θ, and ν are dropped; while ντ, νδ, νθ are dropped and the preceding vowel lengthened (ᾰ to ᾱ, ε to ει, ο to ου).

Bearing these remarks in mind, it should be easy to grasp the declension of the consonant stems which follow.

The parts given of each word will be the nom. sing., acc. sing., gen. sing., and dat. plur. Knowing these, the full declension of each word can be made out with the aid of the table of case-forms given above.

θώραξ	breastplate, masc.	θώρακα	θώρακ-ος	θώραξι
σάλπιγξ	trumpet, fem.	σάλπιγγα	σάλπιγγ-ος	σάλπιγξι
φλέψ	vein, fem.	φλέβα	φλεβ-ός	φλεψί
γίγας	giant, masc.	γίγαντα	γίγαντ-ος	γίγᾱσι
φροντίς	thought, fem.	φροντίδα	φροντίδ-ος	φροντίσι

N.B.—ὄρνις, ὄρνιθος; χάρις, χάριτος; κόρυς, κόρυθος; ἔρις, ἔριδος, all make acc. sing. ending in -ν.

ἅλς	salt, masc.	ἅλα	ἁλ-ός	ἁλσί

Note that in neuter words, which, as we have seen, add no case-ending to the stem in the nom. sing., when the stem ends in -τ, the -τ drops out in the N.V. Acc. sing.

ἅρμα	chariot, neut.	ἅρματ-ος	ἅρμασι

Consonant stems that do not add -ς in the Nominative.—It is to be noted that in the

case of stems ending in -ν, -ρ, or -οντ, the nom. sing., masc. or fem., is constructed in accordance with the following rules :

1. No -ς is added.
2. The vowel of the last syllable of the stem is lengthened.
3. In the case of stems in -οντ, owing to the dislike of Greek for a final -τ, the -τ is dropped.

The following examples will illustrate this :

γέρων	old man, masc.	γέροντα	γέροντ-ος	γέρουσι
λιμήν	harbour, masc.	λιμένα	λιμέν-ος	λιμέσι
Ποσειδῶν	Poseidon, masc.	Ποσειδῶνα	Ποσειδῶν-ος (Voc. Πόσειδον)	
τέρμων	boundary, masc.	τέρμονα	τέρμον-ος	τέρμοσι
δελφίς	dolphin, masc.	δελφῖνα	δελφῖνος	δελφῖσι

Note.—All stems in -ντ are masculine, and most of those in -ν.

ῥήτωρ	orator, masc.	ῥήτορα	ῥήτορ-ος	ῥήτορσι
πατήρ	father, masc.	πατέρα	πατρ-ός	πατράσι

N.B.—In these stems the voc. sing. is formed by using the pure stem. Thus ῥήτωρ has voc. ῥῆτορ, πατήρ has voc. πάτερ.

Like πατήρ are declined μήτηρ, mother; θυγάτηρ, daughter; γαστήρ, belly; Δημήτηρ, Demeter, of which all except πατήρ are fem.—*e.g.*

	Sing.	Dual.	Plur.
Nom.	μήτηρ	μητέρε	μητέρες
Voc.	μῆτερ		μητέρες
Acc.	μητέρα		μητέρας
Gen.	μητρ-ός	μητέροιν	μητέρων
Dat.	μητρί		μητράσι

Stems ending in vowels : -ι and -υ.

Masculine and Feminine

πόλις (fem.), city.

πόλις	πόλει	πόλεις
πόλι		πόλεις
πόλιν		πόλεις
πόλε-ως	πολέοιν	πόλεων
πόλει		πόλεσι

σῦς (com.), pig.

σῦς	σύε	σύες
σῦ		σύες
σῦν		σῦς
συ-ός	συοῖν	συῶν
συΐ		συσί

πέλεκυς (masc.), axe.

πέλεκυς	πελέκεε	πελέκεις
πέλεκυ		πελέκεις
πέλεκυν		πελέκεις
πελέκε-ως	πελεκέοιν	πελέκεων
πελέκει		πελέκεσι

Neuters

ἄστυ (neut.), city.

N.V.A.	ἄστυ	ἄστει	ἄστη
Gen.	ἄστε-ως	ἀστέοιν	ἄστεων
Dat.	ἄστει		ἄστεσι

N.B.—δάκρυ, *tear*, keeps -υ instead of changing it to -ε throughout, and has gen. sing. δάκρυος.

Stems in Diphthongs.—The only diphthong types that are regular are those in -ευ and -ου, *e.g.* :

βασιλεύς (masc.), king.

Nom.	βασιλεύς	βασιλεῖ	βασιλεῖς
Voc.	βασιλεῦ		βασιλεῖς
Acc.	βασιλέα		βασιλέας
Gen.	βασιλέ-ως(βασιλε(F)-ος)	βασιλέοιν	βασιλέων
Dat.	βασιλεῖ		βασιλεῦσι

χοῦς (masc.), a six-pint measure.

Nom.	χοῦς	χόε	χόες
Voc.	χοῦ		χόες
Acc.	χόᾰ		χόας
Gen.	χο-ός	χοοῖν	χοῶν
Dat.	χοΐ		χουσί

Stems in -ο and -ω.—There are three types of these :

αἰδώς (fem.), shame : declined only in the sing.

αἰδώς, αἰδοῖ, αἰδῶ (ο-α), αἰδοῦς (ο-ος), αἰδοῖ.

ἠχώ (fem.), echo : declined only in the sing.

ἠχώ, ἠχοῖ, ἠχώ (ο-α), ἠχοῦς (ο-ος), ἠχοῖ.

δμώς (masc.), slave.

N.V.	δμώς	δμῶε	δμῶες (δμῶς)
Acc.	δμῶα (δμῶ)		δμῶας (δμῶς)
Gen.	δμω-ός	δμώοιν	δμώων
Dat.	δμωΐ (δμῴ)		δμωσί

Stems that reject their Final Consonant.—One of the peculiarities of Greek pronunciation was that **σ** between two vowels was repulsive to it and tended to drop out. Hence the declension of some nouns whose stem ends in **-σ**, where the **σ** drops and the two vowels that then come together are contracted into one sound.

τεῖχος (neut.), wall.

N.V.A.	τεῖχος	τείχη (-ε(σ)-ε)	τείχη (-ε(σ)-α)
Gen.	τείχους (τειχε(σ)-ος)	τειχοῖν (-ε(σ)-οιν)	τειχῶν (-ε(σ)-ων)
Dat.	τείχει (τειχε(σ)-ι)		τείχεσι

Δημοσθένης (masc.), Demosthenes.

Nom.	Δημοσθένης
Voc.	Δημόσθενες
Acc.	Δημοσθένη (-ε(σ)-α) (often Δημοσθένην)
Gen.	Δημοσθένους (-ε(σ)-ος)
Dat.	Δημοσθένει (-ε(σ)-ι)

Some stems in -τ drop it between two vowels:

κέρας (neut.), horn, wing of an army.

N.V.A.	κέρας	κέρα	κέρα
Gen.	κέρως	κέρῳν	κερῶν
Dat.	κέρᾳ		κέρασι

Neuter stems in -αρτ drop τ in the N.V.A. sing., and drop ρ in the other cases, *e.g.*:

ἧπαρ	liver, neut.	Gen.	ἥπατος, &c.
ὕδωρ	water, neut.	Gen.	ὕδατος, &c.

The following nouns are *irregular*, *i.e.* cannot be grouped into a class with others according to a recognised scheme of declension:

γραῦς (fem.), old woman.

Nom.	γραῦς	γρᾶε	γρᾶες
Voc.	γραῦ		γρᾶες
Acc.	γραῦν		γραῦς
Gen.	γρᾱ-ός	γραοῖν	γραῶν
Dat.	γρᾱΐ		γραυσί

ναῦς (fem.), ship.

Nom.	ναῦς	νῆε	νῆες
Voc.	ναῦ		νῆες
Acc.	ναῦν		ναῦς
Gen.	νε-ώς	νεοῖν	νεῶν
Dat.	νηΐ		ναυσί

ἔαρ (neut.), spring.

N.V.A. ἔαρ Gen. ἦρος Dat. ἦρι

Ζεύς (masc.), Zeus.

Nom. Ζεύς. Voc. Ζεῦ. Acc. Δία. Gen. Δι-ός. Dat. Διί.

κλείς (fem.), key.

N.V. κλείς. Acc. κλεῖν. Gen. κλειδ-ός, &c.

θρίξ (fem.), hair.

N.V. θρίξ. Acc. τρίχ-α, &c. Dat. plur. θριξί.

ἀνήρ (masc.), man.

Nom. ἀνήρ. Voc. ἄνερ. Acc. ἄνδρ-α, &c. Dat. plur. ἀνδράσι.

γόνυ (neut.), knee.

N.V.A. γόνυ. Gen. γόνατ-ος, &c. Dat. plur. γόνασι.

γυνή (fem.), woman.

Nom. γυνή. Voc. γύναι. Acc. γυναῖκ-α &c.

γάλα (neut.), milk.

N.V.A. γάλα. Gen. γάλακτ-ος, &c.

γέρας (neut.), privilege.

Sing. N.V.A. γέρας. Gen. γέρως. Dat. γέρᾳ.
Plur. N.V.A. γέρᾱ. Gen. γερῶν. Dat. γέρασι.

γῆρας (neut.), old age.

N.V.A. γῆρας. Gen. γήρως. Dat. γήρᾳ. No plural.

κρέας (neut.), meat.

Sing. N.V.A. κρέας. Gen. κρέως. Dat. κρέᾳ.
Plur. N.V.A. κρέα. Gen. κρεῶν. Dat. κρέασι.

κνέφας (neut.), murk.

N.V.A. κνέφας. Gen. κνέφους. Dat. κνέφᾳ. No plural.

κύων (com.), dog.

Nom. κύων. Voc. κύον. Acc. κύνα, &c. Dat. plur. κυσί.

οὖς (neut.), ear.

N.V.A. οὖς. Gen. ὠτ-ός, &c.

πούς (masc.), foot.

N.V. πούς. Acc. πόδ-α, &c. Dat. plur. ποσί.

πῦρ (neut.), fire.

N.V.A. πῦρ. Gen. πυρ-ός, &c. Dat. plur. πυροῖς.

ὕδωρ (neut.), water.

N.V.A. ὕδωρ. Gen. ὕδατ-ος, &c.

υἱός (masc.), son.

Sing. Nom. υἱός. Voc. υἱέ. Acc. υἱόν. Gen. υἱοῦ, υἱέος. Dat. υἱῷ, υἱεῖ.
Dual. N.V.A. υἱῆ. Gen. Dat. υἱέοιν.
Plur. N.V.A. υἱεῖς. Gen. υἱέων. Dat. υἱέσι.

φρέαρ (neut.), tank.

N.V.A. φρέαρ. Gen. φρέᾱτ-ος, &c. Dat. plur. φρέασι.

χείρ (fem.), hand.

N.V. χείρ. Acc. χεῖρ-α, &c. Dat. plur. χερσί.

The Definite Article

ὁ, ἡ, τό, the.

	Masculine.	Feminine.	Neuter.
	Singular.		
Nom.	ὁ	ἡ	τό
Acc.	τόν	τήν	τό
Gen.	τοῦ	τῆς	τοῦ
Dat.	τῷ	τῇ	τῷ
	Dual.		
N.A.	τώ	τώ	τώ
G.D.	τοῖν	τοῖν	τοῖν
	Plural.		
Nom.	οἱ	αἱ	τά
Acc.	τούς	τάς	τά
Gen.	τῶν	τῶν	τῶν
Dat.	τοῖς	ταῖς	τοῖς

Translate, giving every possible meaning of—
ἡ χώρα: τοῦ βασιλέως: τοῖς ποσίν: ὄρνιθος: πῦρ καὶ ὕδωρ: τῇ τοῦ Διός χειρί: οἱ τοῦ ἀγγέλου λόγοι: τὸ τῆς ἀρετῆς κάλλος: οἱ τῆς νεώς ναῦται: τὰ τοῦ Δημοσθένους ἔργα: τώ τῆς γυναικός υἱῆ: ἡ τοῦ Κύρου μήτηρ τοῦ τῶν Μήδων βασιλέως.

(*N.B.*—Note the use of the following prepositions: **ἐν** = *in*, takes the dative case; **ἐκ** = *out of, from*, takes the genitive; **διά** = *through* (of space), takes the genitive; **διά** = *on account of*, takes the accusative.)

Nom. λιμήν	Gen. λιμέν-ος, &c.
Nom. τέρμων	Gen. τέρμον-ος, &c.
Nom. ῥήτωρ	Gen. ῥήτορ-ος, &c.

At first this vowel-gradation is extremely puzzling; some words seem to vary their spelling and others to keep it unchanged according to the vagaries of some mysterious chance.

There is, however, a definite principle underlying this vowel-gradation, and when this is understood, all the regular and most of the so-called irregular words become plain and straightforward in their declension. In the original Indo-Germanic language from which Greek, in common with most of the European languages, is derived, an accented short syllable was lengthened if the syllable following it was lost. Now the stem-suffixes, *-εν, -ον, -μεν, -μον, -ερ, -ορ, -τερ, -τορ,* and *-ντ* appear originally to have had the forms *-ενο, -ονο, -μενο, -μονο,* &c. The second syllable came to be dropped in many words, with the result that, according to the rule just enunciated, the first syllable has been lengthened.

Thus there was originally a nominative *ποιμενο,* in which the Indo-Germanic accent fell on the second syllable. Then, owing to some change in the language not yet understood, the *-ο* was lost and the preceding *-εν* became *-ην*. In the other cases there is another syllable following the stem-suffix, so that the form *-μεν* is retained.

In the case of the vocative, there was originally no accent at all, so that the rule did not apply; and the stem-vowel underwent no change.

The declension of such a word as *ῥήτωρ, ῥῆτορ, ῥήτορα* is thus easily understood.

A further apparent anomaly is shown in the declension of *μήτηρ* and the group of words that resemble it. The change from *μήτηρ* in the nom. to *μῆτερ, μητέρα* in the voc. and acc. is explained by the rule discussed above. There still remain, however, to perplex the student the forms *μητρός, μητρί,* and *μητράσιν,* and to understand these it is necessary to go back once more to the original Indo-Germanic language.

Originally there were two sorts of accent used in speaking—pitch accent, indicated by the varying pitch of the voice; and stress accent, indicated by the force or absence of force with which the syllable was pronounced. In Greek itself, only pitch accent was used, but the original stress accent had an effect on the form of words which can be directly traced in Greek. The absence of the principal stress accent led naturally to the appearance of a syllable in its lowest pronounceable form. In the gen. and dat. sing. and the dat. plur. the original stress accent fell on the last syllable, and the last syllable but one had no stress at all, and tended to appear as a result in its weakest pronounceable form. Hence the stressed *-τερ-* of *πατέρα* became *-τρ-* in *πατρός,* when it was not stressed at all. In the dat. plur. the syllable *-τρ-* was followed, not by a vowel as in the gen. and dat. sing., but by a consonant. In those circumstances, as will be found by experiment, the only way in which it could be pronounced was by inserting a weak vowel such as ᾰ between the *-ρ-* and the following consonant, and this gives us *πα-τρά-σιν.*

Another example to illustrate this is found in Pindar, where *φρασί* is used as the dat. plur. of *φρήν, φρενός, φρα-* being the lowest pronounceable form in which Greek could put the syllable *φρεν-.*

Adjectives.—The function of an adjective is to add a quality to a substantive. Therefore we find in an inflected language such as Greek that an adjective is made to correspond to its noun in *number, gender,* and *case.*

Consequently adjectives must be declined, and in Greek they have case-forms similar to those of substantives, which fall into three groups:

1. 1st and 2nd Declensions.
2. 1st and 3rd Declensions.
3. 3rd Declension.

1. *Adjectives of the* 1*st and* 2*nd Declensions.*—Adjectives of this declension can be subdivided into four types:

(*a*) Masculine like *λόγος.*
Feminine like *λήθη.*
Neuter like *ἔργον.*

(*b*) Masculine like *λόγος.*
Feminine like *θύρα.*
Neuter like *ἔργον.*

(*c*) Contracted words:
Masculine like *νοῦς.*
Feminine of a special type.
Neuter like *ὀστοῦν.*

(*d*) Masculine and feminine, like *λεώς.*
Neuter of the same type.

(*a*) *καλός,* beautiful.

MASCULINE.	FEMININE.
καλός	καλή
(declined like λόγος).	(declined like λήθη).

NEUTER.

καλόν
(declined like ἔργον).

(*b*) ἐχθρός, hateful.

Masculine.	Feminine.
ἐχθρός	ἐχθρά
(declined like λόγος).	(declined like θύρα).

Neuter.

ἐχθρόν
(declined like ἔργον).

(*c*) διπλοῦς (διπλόος), double.

Masculine.	Feminine.			
		Sing.	Dual.	Plur.
διπλοῦς	N.V.	διπλῆ	διπλώ	διπλαῖ
(declined like νοῦς)	Acc.	διπλῆν		διπλᾶς
	Gen.	διπλῆς	διπλοῖν	διπλῶν
	Dat.	διπλῇ		διπλαῖς

Neuter.

διπλοῦν
(declined like ὀστοῦν).

N.B.—Adjectives in -εος contracted to -ους have -α instead of -η in the fem. sing. when the preceding letter is ρ or a vowel—*e.g.* ἀργυροῦς (of silver) makes fem. ἀργυρᾶ.

(*d*) ἵλεως, gracious.

Masc. and Fem.	Neuter.			
		Sing.	Dual.	Plur.
ἵλεως	N.V.A.	ἵλεων	ἵλεω	ἵλεω
(declined like λεώς)	Gen.	ἵλεω	ἵλεῳν	ἵλεων
	Dat.	ἵλεῳ		ἵλεῳς

Note.—It should be noted that there is also a large class of compound adjectives (*i.e.* made up of two or more simple words) which have only two endings—-ος in the masc. and fem. and -ον in the neuter.

2. *Adjectives of the 1st and 3rd Declensions.*—Adjectives coming under this head form their masc. and neut. according to the 3rd Declension, and form the fem. by adding -ια to the stem.

The principal type of adjectives pure and simple in this class is that of the -υ stems, *e.g.*:

γλυκύς, sweet (to the taste).

	Masculine.	Feminine.	Neuter.
		Singular.	
N.V.	γλυκύς	γλυκεῖα (-υ-ια)	γλυκύ
Acc.	γλυκύν	γλυκεῖαν	γλυκύ
Gen.	γλυκέος	γλυκείᾱς	γλυκέος
Dat.	γλυκεῖ	γλυκείᾳ	γλυκεῖ
		Dual.	
N.V.A.	γλυκέε	γλυκείᾱ	γλυκέε
G.D.	γλυκέοιν	γλυκείαιν	γλυκέοιν
		Plural.	
N.V.	γλυκεῖς	γλυκεῖαι	γλυκέα
Acc.	γλυκεῖς	γλυκείᾱς	γλυκέα
Gen.	γλυκέων	γλυκειῶν	γλυκέων
Dat.	γλυκέσι	γλυκείαις	γλυκέσι

A less numerous type is that of stems in -ν, *e.g.*:

τέρην, tender.

	Masculine.	Feminine.	Neuter.
N.V.	τέρην	τέρεινα (*i.e.* τερεν-ια)	τέρεν
Acc.	τέρενα	τέρειναν	τέρεν
Gen.	τέρενος	τερείνης	τέρενος
	&c.	&c.	&c.

Of great importance is the large class of participles which are declined as of the 3rd Declension in the masc. and neut. and as of the 1st in the fem. The majority of them have stems ending in -ντ, and, allowing for differences of stem-vowel, knowledge of the declension of one will enable the student to decline the others.

πράττων, doing (Present Participle).

	Masculine.	Feminine.	Neuter.
		Singular.	
N.V.	πράττων	πράττουσα	πρᾶττον
Acc.	πράττοντα	πράττουσαν	πρᾶττον
Gen.	πράττοντος	πραττούσης	πράττοντος
Dat.	πράττοντι	πραττούσῃ	πράττοντι
		Dual.	
N.V.A.	πράττοντε	πραττούσᾱ	πράττοντε
G.D.	πραττόντοιν	πραττούσαιν	πραττόντοιν
		Plural.	
N.V.	πράττοντες	πράττουσαι	πράττοντα
Acc.	πράττοντας	πραττούσας	πράττοντα
Gen.	πραττόντων	πραττουσῶν	πραττόντων
Dat.	πράττουσι	πραττούσαις	πράττουσι

Similarly are declined the types represented by the following:

πράξας, πράξᾱσα, πρᾶξαν, doing (referring to past action), aor. part. act.
πραχθείς, πραχθεῖσα, πραχθέν, done, aor. part. pass.
διδούς, διδοῦσα, διδόν, giving.
δεικνῡ́ς, δεικνῦσα, δεικνύν, showing.

There are also a few non-participle adjectives with stems in -ντ- declined after the following type:

Nom.	χαρίεις	χαρίεσσα	χαρίεν	graceful
Voc.	χαρίεν	χαρίεσσα	χαρίεν	
Acc.	χαρίεντα	χαρίεσσαν	χαρίεν	
	&c.	&c.	&c.	

Finally comes the type of participles with stem ending in -οτ-, *e.g.*:

λελυκώς (perf. part. act.), having loosed.

N.V.	λελυκώς	λελυκυῖα	λελυκός
Acc.	λελυκότα	λελυκυῖαν	λελυκός
	&c.	&c.	&c.
D.Pl.	λελυκόσι	λελυκυίαις	λελυκόσι

3. *Adjectives of the 3rd Declension.*—(*a*) -εσ-stems:

εὐμενής, gracious.

	Masculine and Feminine.	Neuter.
	Singular.	
N.V.	εὐμενής	εὐμενές
Acc.	εὐμενῆ	εὐμενές
Gen.	εὐμενοῦς	εὐμενοῦς
Dat.	εὐμενεῖ	εὐμενεῖ

Masculine and Feminine.		Neuter.
	Dual.	
N. V. A.	εὐμενῆ	εὐμενῆ
G.D.	εὐμενοῖν	εὐμενοῖν
	Plural.	
N.V.A.	εὐμενεῖς	εὐμενῆ
Gen.	εὐμενῶν	εὐμενῶν
Dat.	εὐμενέσι	εὐμενέσι

(b) -ον- stems:

κακόφρων, malicious.

	Masc. and Fem.	Neuter.
	Singular.	
N.V.	κακόφρων	κακόφρον
Acc.	κακόφρονα	κακόφρον
Gen.	κακόφρονος	
Dat.	κακόφρονι	
	Dual.	
N.V.A.	κακόφρονε	
G.D.	κακοφρόνοιν	
	Plural.	
N.V.	κακόφρονες	κακόφρονα
Acc.	κακόφρονας	κακόφρονα
Gen.	κακοφρόνων	
Dat.	κακόφροσι	

Note.—Comparatives in -ων have alternative endings as follows:

	Masc. and Fem.	Neuter.
	Singular.	
Acc.	-ονα, -ω	
	Plural.	
N.V.	-ονες, -ους	-ονα, -ω
Acc.	-ονας, -ους	-ονα, -ω

A few adjectives are declined irregularly with two stems after the following type:

πολύς, much.

	Masc.	Fem.	Neuter.
		Singular.	
N.V.	πολύς	πολλή	πολύ
Acc.	πολύν	πολλήν	πολύ
Gen.	πολλοῦ	πολλῆς	πολλοῦ
Dat.	πολλῷ	πολλῇ	πολλῷ
		Plural.	
N.V.	πολλοί &c.	πολλαί &c.	πολλά &c.

The only other example in common use is:

μέγας, μεγάλη, μέγα, great.

Comparison of Adjectives.—There are in Greek, as in English, three degrees of comparison, viz. Positive, Comparative, and Superlative.

e.g. Good is positive, stating that the quality exists.

Better is comparative, comparing the thing described with something else.

Best is superlative, stating the existence of the quality in its greatest extent.

The commonest method of comparison in Greek is to add to the stem the ending -τερος, -τερα, -τερον to form the comparative, and -τατος, -τατη, -τατον to form the superlative.

In -ο stems the -ο is lengthened to -ω if the preceding syllable is short—*e.g.*:

πονηρό-ς	wicked	πονηρό-τερος	πονηρό-τατος
λόγιο-ς	learned	λογιώ-τερος	λογιώ-τατος
γλυκύ-ς	sweet	γλυκύ-τερος	γλυκύ-τατος
τέρην	tender	τερέν-τερος	τερέν-τατος
εὐμενής	gracious	εὐμενέσ-τερος	εὐμενέσ-τατος

Adjectives whose stems end in -αιο- drop the -ο- in comparison—*e.g.*:

παλαιός	ancient	παλαίτερος	παλαίτατος.

Adjectives whose stems end in -ον form the comparative and superlative by adding -εστερος and -εστατος respectively—*e.g.*:

κακόφρων	malicious	κακοφρονέστερος	κακοφρονέστατος

Irregular Comparison.—Some adjectives are irregular in their comparison. The following are the most important examples:

Positive.		Comparative.	Superlative.
ἀγαθός	good	ἀμείνων	ἄριστος
		βελτίων	βέλτιστος
κακός	bad	κακίων	κάκιστος
μικρός	small	μείων	
		μικρότερος	μικρότατος
ὀλίγος	little		ὀλίγιστος
		ἐλάττων	ἐλάχιστος
φίλος	beloved	φίλτερος	φίλτατος
εὔνους	kind	εὐνούστερος	εὐνούστατος
πολύς	much	πλείων	πλεῖστος
καλός	beautiful	καλλίων	κάλλιστος
ἡδύς	sweet	ἡδίων	ἥδιστος
ῥᾴδιος	easy	ῥᾴων	ῥᾷστος
ταχύς	swift	θάττων	τάχιστος
ἐχθρός	hostile	ἐχθίων	ἔχθιστος
ἀλγεινός	painful	ἀλγίων	ἄλγιστος
μέγας	great	μείζων	μέγιστος
αἰσχρός	disgraceful	αἰσχίων	αἴσχιστος

Translate, giving every possible meaning of: ὁ Σωκράτης ὁ πάντων ἀνθρώπων σοφώτατος. αἰσχρὸν ἔργον. ὦ φίλτατ' ἀνδρῶν. ἡ καλῆς μητρὸς καλλίων θυγάτηρ. τὸ ὕδωρ, τὸ ἄριστον τοῖς σώφροσι ποτόν.

(*N.B.*—Note the very common and idiomatic use of μέν, a conjunctive particle, used to distinguish the word or clause with which it stands from something that is to follow, and δέ which generally answers it in the corresponding clause, the general sense being "on the one hand . . . on the other . . .")

τὸ μὲν πνεῦμα πρόθυμον ἡ δὲ σὰρξ ἀσθενής. πρῶτος καὶ μέγιστος ποιητῶν ὁ Ὅμηρος. ἔργον ῥᾴδιον μὲν ἀλλ' οὐ γλυκὺ ταις εὔναις γυναιξίν. πόλεμος χρησιμώτερος τοῖς Ἀθηναίοις. πάντες οἱ τῶν Θηβῶν πολῖται. ἀγαθοῦ λεὼ ἀγαθὸς ἄναξ. ὁ χρυσὸς πολλῶν κακῶν ἀρχή. ὁ Ζεῦς ὁ παντῶν τῶν θεῶν κράτιστος. ἡ γλυκεῖα μακαίρας γυναικὸς φωνή.

Adverbs.—Adverbs are regularly formed from adjectives by adding tho ending *-ως* to the stem, subject to the following rules:

1. In forming adverbs from *-ο* stems the *-ο* is dropped.
   (*E.g.* the adverb formed from *καλό-ς*, good, is *καλ-ῶς*, well.)
2. In forming adverbs from adjectives of the 3rd Declension, that form of the stem is used which appears in the gen. sing. masc.
   (*E.g.* the stem of *σαφής*, clear, is really *σαφεσ-*, but the gen. sing. masc. is *σαφέ-ος*, hence the adverb meaning "clearly" is *σαφῶς*, contracted from *σαφέ-ως*.)

Comparison of Adverbs.—The comparative of an adverb is the acc. sing. neut. of the comparative of the adjective. The superlative of an adverb is the acc. plur. neut. of the superlative of the adjective.

σοφῶς wisely	σοφώτερον more wisely	σοφώτατα most wisely	
κακῶς badly	κακίον	κάκιστα	
φίλως	φίλτερον	φίλτατα	
ταχέως	θᾶττον	τάχιστα	

Besides the adverbs in *-ως*, formed regularly from adjectives, there are many others formed from nouns and verbs. Of these the commonest is the use of the dat. sing. of nouns in an adverbial sense—*e.g.* *ἡ σπουδή*, zeal, gives us *σπουδῇ*, zealously.

Another adverbial ending on noun-stems is *-δον*, and many adverbs are formed by adding to verb-stems the endings *-δην* or *-τι*.

There are three suffixes that go to form adverbs of place, viz.:

-ι added to the stem, indicating "where."
-θεν added to the stem, indicating "whence."
-δε added to the accusative, indicating "whither."

Finally there are many adverbs for the formation of which no general principle is apparent—*e.g.* *αὖθις*, again; *τότε*, then; *ἐκεῖ*, there, &c.

Numerals.—There are three classes of numerals, viz.:

1. *Cardinals*, which tell how many there are.
2. *Ordinals*, which tell in what order they come.
3. *Numeral Adverbs*, which tell how many times a thing happened.

Not.		Cardinal.	Ordinal.	Adverb.
1.	α'	εἷς, μία, ἕν, one	πρῶτος, first	ἅπαξ, once
2.	β'	δύο	δεύτερος	δίς
3.	γ'	τρεῖς, τρία	τρίτος	τρίς
4.	δ'	τέτταρες, τέτταρα	τέταρτος	τετράκις
5.	ε'	πέντε	πέμπτος	πεντάκις
6.	ς'	ἕξ	ἕκτος	ἑξάκις
7.	ζ'	ἑπτά	ἕβδομος	ἑπτάκις
8.	η'	ὀκτώ	ὄγδοος	ὀκτάκις
9.	θ'	ἐννέα	ἔνατος	ἐνάκις
10.	ι'	δέκα	δέκατος	δεκάκις
11.	ια'	ἕνδεκα	ἑνδέκατος	ἑνδεκάκις
12.	ιβ'	δώδεκα	δωδέκατος	δωδεκάκις
13.	ιγ'	τρεῖς καὶ δέκα	τρίτος καὶ δέκατος	τρισκαιδεκάκις
14.	ιδ'	τέτταρες καὶ δέκα	τέταρτος καὶ δέκατος	τετταρεσκαι-δεκάκις
15.	ιε'	πεντεκαίδεκα	πέμπτος καὶ δέκατος	πεντεκαιδεκά-κις
16.	ις'	ἑκκαίδεκα	ἕκτος καὶ δέκατος	ἑκκαιδεκάκις
20.	κ'	εἴκοσι(ν)	εἰκοστός	εἰκοσάκις
21.	κα'	εἴκοσιν εἷς	εἰκοστὸς πρῶτος	εἰκοσάκις ἅπαξ
30.	λ'	τριάκοντα	τριακοστός	τριακοντάκις
40.	μ'	τετταράκοντα	τετταρακοστός	τετταρακοντάκις
50.	ν'	πεντήκοντα	πεντηκοστός	πεντηκοντάκις
60.	ξ'	ἑξήκοντα	ἑξηκοστός	ἑξηκοντάκις
70.	ο'	ἑβδομήκοντα	ἑβδομηκοστός	ἑβδομηκοντάκις
80.	π'	ὀγδοήκοντα	ὀγδοηκοστός	ὀγδοηκοντάκις
90.	ϟ'	ἐνενήκοντα	ἐνενηκοστός	ἐνενηκοντάκις
100.	ρ'	ἕκατον	ἑκατοστός	ἑκατοντάκις
200.	σ'	διακόσιοι, -αι, -α	διακοσιοστός	διακοσιάκις
1,000.	͵α	χίλιοι, -αι, -α	χιλιοστός	χιλιάκις
2,000.	͵β	δισχίλιοι	δισχιλιοστός	δισχιλιάκις
10,000.	͵ι	μύριοι, -αι, -α	μυριοστός	μυριάκις

εἷς, μία, ἕν, one, is declined as follows:

	Masculine.	Feminine.	Neuter.
Nom.	εἷς	μία	ἕν
Acc.	ἕνα	μίαν	ἕν
Gen.	ἑνός	μιᾶς	ἑνός
Dat.	ἑνί	μιᾷ	ἑνί

δύο, two, is declined thus:

N.A.	δύο
G.D.	δυοῖν

τρεῖς, three, is declined:

	Masc. and Fem.	Neuter.
N.A.	τρεῖς	τρία
Gen.	τριῶν	τριῶν
Dat.	τρισί	τρισί

τέτταρες, four, is declined:

	Masc. and Fem.	Neuter.
Nom.	τέτταρες	τέτταρα
Acc.	τέτταρας	τέτταρα
Gen.	τεττάρων	τεττάρων
Dat.	τέτταρσι	τέτταρσι

Like *εἷς* are declined *οὐδείς, οὐδεμία, οὐδέν*, and *μηδείς*, &c., which mean "no one." These negatives, however, also are declined in the plural.

None of the other cardinals are declined down to *χίλιοι*, &c., which are declined like the plural of *καλός*.

All the ordinals are declined like *καλός*.

Pronouns.—*Personal Pronouns* :

	1st Person. Sing.	Dual.	Plur.	2nd Person. Sing.	Dual.	Plur.
Nom.	ἐγώ	νώ	ἡμεῖς	σύ	σφώ	ὑμεῖς
Voc.	—	—	—	σύ	σφώ	ὑμεῖς
Acc.	ἐμέ, με	νώ	ἡμᾶς	σέ	σφώ	ὑμᾶς
Gen.	ἐμοῦ, μου	νῷν	ἡμῶν	σοῦ	σφῷν	ὑμῶν
Dat.	ἐμοί, μοι	νῷν	ἡμῖν	σοί	σφῷν	ὑμῖν

The nominative of the personal pronoun of the 3rd Person is not found. For the other cases Greek used the oblique cases of *αὐτός*, self, which is declined as follows :

	Masc.	Fem.	Neut.	Masc.	Fem.	Neut.
	Singular.			Plural.		
Nom.	αὐτός	αὐτή	αὐτό	αὐτοί	αὐταί	αὐτά
Acc.	αὐτόν	αὐτήν	αὐτό	αὐτούς	αὐτάς	αὐτά
Gen.	αὐτοῦ	αὐτῆς	αὐτοῦ	αὐτῶν	αὐτῶν	αὐτῶν
Dat.	αὐτῷ	αὐτῇ	αὐτῷ	αὐτοῖς	αὐταῖς	αὐτοῖς

Note.—When *αὐτός* is placed between the article and its substantive it takes the meaning "same," *e.g.* *ἡ αὐτὴ γυνή*, the same woman. When the particular form of the article used ends in a vowel it often merges into the first syllable of the pronoun, *e.g.* *αὑτὸς ἀνήρ* = the same man ; *ταὐτῇ ἡμέρᾳ* = on the same day. When *αὐτός* is used in an intensive sense like *ipse* in Latin, it comes before the article, *e.g.* *αὐτὴ ἡ γυνή* = the woman herself.

The Reflexive Pronouns :

Myself.

	Masculine.	Feminine.
Acc.	ἐμαυτόν	ἐμαυτήν
Gen.	ἐμαυτοῦ	ἐμαυτῆς
Dat.	ἐμαυτῷ	ἐμαυτῇ

Ourselves.

Acc.	ἡμᾶς αὐτούς	ἡμᾶς αὐτάς
Gen.	ἡμῶν αὐτῶν	ἡμῶν αὐτῶν
Dat.	ἡμῖν αὐτοῖς	ἡμῖν αὐταῖς

Thyself.

Acc.	σεαυτόν, σαυτόν	σεαυτήν, σαυτήν
Gen.	σεαυτοῦ, σαυτοῦ	σεαυτῆς, σαυτῆς
Dat.	σεαυτῷ, σαυτῷ	σεαυτῇ, σαυτῇ

Yourselves.

Acc.	ὑμᾶς αὐτούς	ὑμᾶς αὐτάς
Gen.	ὑμῶν αὐτῶν	ὑμῶν αὐτῶν
Dat.	ὑμῖν αὐτοῖς	ὑμῖν αὐταῖς

N.B.—The contracted forms *σαυτόν*, &c., are more common in Attic Greek.

Himself, herself, itself.

Acc.	ἑαυτόν	ἑαυτήν	ἑαυτό
Gen.	ἑαυτοῦ	ἑαυτῆς	ἑαυτοῦ
Dat.	ἑαυτῷ	ἑαυτῇ	ἑαυτῷ

Themselves.

Acc.	ἑαυτούς	ἑαυτάς	ἑαυτά
Gen.	ἑαυτῶν	ἑαυτῶν	ἑαυτῶν
Dat.	ἑαυτοῖς	ἑαυταῖς	ἑαυτοῖς

Possessives.—The personal pronouns of the 1st and 2nd Person have each an adjectival form with a possessive meaning.

Thus—

to ἐγώ	corresponds	ἐμός	declined like	καλός.
„ σύ	„	σός	„	„
„ ἡμεῖς	„	ἡμέτερος	„	ἐχθρός
„ ὑμεῖς	„	ὑμέτερος	„	„

Demonstrative Pronouns :

οὗτος, this.

	Masculine.	Feminine.	Neuter.
	Singular.		
Nom.	οὗτος	αὕτη	τοῦτο
Acc.	τοῦτον	ταύτην	τοῦτο
Gen.	τούτου	ταύτης	τούτου
Dat.	τούτῳ	ταύτῃ	τούτῳ
	Dual.		
N.A.	τούτω	τούτω	τούτω
G.D.	τούτοιν	τούτοιν	τούτοιν
	Plural.		
Nom.	οὗτοι	αὗται	ταῦτα
Acc.	τούτους	ταύτας	ταῦτα
Gen.	τούτων	τούτων	τούτων
Dat.	τούτοις	ταύταις	τούτοις

ὅδε, "this," is declined like the definite article, each case being followed by *δε*. *ἐκεῖνος*, "that," is declined like *αὐτός*.

The Reciprocal Pronoun ("each other") :

	Masculine.	Feminine.	Neuter.
	Dual.		
Acc.	ἀλλήλω	ἀλλήλω	ἀλλήλω
G.D.	ἀλλήλοιν	ἀλλήλοιν	ἀλλήλοιν
	Plural.		
Acc.	ἀλλήλους	ἀλλήλας	ἄλληλα
Gen.	ἀλλήλων	ἀλλήλων	ἀλλήλων
Dat.	ἀλλήλοις	ἀλλήλαις	ἀλλήλοις

The Relative Pronoun.—*ὅς*, "who," is declined as follows :

	Masculine.	Feminine.	Neuter.
	Singular.		
Nom.	ὅς	ἥ	ὅ
Acc.	ὅν	ἥν	ὅ
Gen.	οὗ	ἧς	οὗ
Dat.	ᾧ	ᾗ	ᾧ
	Dual.		
N.A.	ὥ	ὥ	ὥ
G.D.	οἷν	οἷν	οἷν
	Plural.		
Nom.	οἵ	αἵ	ἅ
Acc.	οὕς	ἅς	ἅ
Gen.	ὧν	ὧν	ὧν
Dat.	οἷς	αἷς	οἷς

Another form of the relative pronoun is *ὅσπερ*, which is declined in the same way, with the addition of *-περ* at the end of each case.

The Indefinite Pronoun :

τις, "anyone."

	Masc. and Fem.	Neuter.
	Singular.	
Nom.	τις	τι
Acc.	τινά	τι
Gen.	τινός or του	
Dat.	τινί or τῳ	
	Dual.	
N.A.	τινέ	
G.D.	τινοῖν	

	Masc. and Fem.	Neuter.
	Plural.	
Nom.	τινές	τινά
Acc.	τινάς	τινά
Gen.	τινῶν	
Dat.	τισί	

The Interrogative Pronoun.—τίς, "who?" is the same in form as the indefinite pronoun except that the interrogative always carries an accent when monosyllabic, and when dissyllabic puts the accent on the first syllable instead of the last.

The relative and indefinite pronouns are combined to form a relative ὅστις = "whoever," the declension of which is peculiar and should be carefully noted.

	Masculine.	Feminine.	Neuter.
		Singular.	
Nom.	ὅστις	ἥτις	ὅτι
Acc.	ὅντινα	ἥντινα	ὅτι
Gen.	ὅτου	ἧστινος	ὅτου
Dat.	ὅτῳ	ᾗτινι	ὅτῳ
		Dual.	
N.A.	ὥτινε	ὥτινε	ὥτινε
G.D.	ὅτοιν	ὅτοιν	ὅτοιν
		Plural.	
Nom.	οἵτινες	αἵτινες	ἅττα
Acc.	οὕστινας	ἅστινας	ἅττα
Gen.	ὅτων	ὅτων	ὅτων
Dat.	ὅτοις	αἷστισι	ὅτοις

Note.—Note that in writing Greek the sign of interrogation used is the English semicolon, *e.g.* Who is the man? τίς ἐστιν ὁ ἀνήρ;

The Verb.—Verbs, like nouns, are in Greek subject to inflexion, which in their case is called Conjugation. By means of conjugation are expressed:

1. *Person* and *Number*.
2. *Voice*.—Active, Middle, or Passive.

The Active Voice indicates that the action of the verb proceeds from the subject, *e.g.* λύω = I loose.

The Middle Voice indicates that the action of the verb proceeds from the subject and is directed towards the subject, *e.g.* λύομαι = I loose for myself.

The Passive Voice indicates that the action of the verb is directed towards the subject and proceeds from a source outside it, *e.g.* λύομαι = I am loosed.

Note.—Some verbs are only found in one voice. Of these some are Middle in form and Active in meaning. Such are called deponents.

Some verbs, again, have a future tense that is Middle in form but Active in meaning.

3. *Tense.*—Present, Future, Perfect, Future Perfect, Imperfect, Aorist, Pluperfect.

The *Present* tense denotes the existence of a fact or the continuance of an action at the moment of speaking, as "I am here," "He is walking."

The *Future* tense denotes what will happen at a time later than the moment of speaking, as "He will tell us to-morrow."

The *Perfect* tense denotes an action or state of things which began in the past and is completed at the moment of speaking, *e.g.* "I have eaten my dinner"—*i.e.* "I began to eat it and went on eating, and now, at the time when I speak, it is actually all eaten."

The *Future Perfect* denotes that at some time in the future the subject of the verb will be able to say, "I have done so-and-so," *e.g.* "To-morrow I shall have gone away."

These tenses are known as *Principal* tenses. The remaining tenses, which are known as *Historic*, are:

The *Imperfect*, which denotes that at a specific time in the past an action was being carried on or a state of things was continuing to exist, *e.g.* "He was for three years in charge of the office," or "I used to like listening to him."

The *Aorist*, which denotes the plain fact that at a point of time in the past a thing was done or an occurrence took place, *e.g.* "He was killed," "The horse ran away."

The *Pluperfect*, which denotes that at a moment in the past an action or state of things which had begun before then was at an end, *e.g.* "When he was found he had given up hope."

4. *Mood.*—Indicative, Subjunctive, Optative, Imperative.

The *Indicative* mood states a fact—"I come."

The *Subjunctive* represents futurity.

The *Optative* is used to express in a less definite sense most of the constructions of the other moods.

The *Imperative* is the mood of command, *e.g.* λῦέ με = loose me.

There are also the following verbal substantives:

The *Infinitive*, *e.g.* φιλεῖν = to love.

The *Participles*, *e.g.* φιλῶν = loving.

The *Verbal Adjectives*, *e.g.* φιλητέος ἐστι = he should be loved.

The Formation of the Verb.—Conjugation, like Declension, consists in affixing various endings to the stem in order to express various shades of meaning.

For the purposes of conjugation Greek verbs divide themselves into two classes:

1. Verbs ending in -ω in the pres. indic. act.
2. Verbs ending in -μι in the pres. indic. act.

Of these, those in -ω are the larger class, and will therefore be dealt with first.

Verbs in -ω.

The following is a completely inflected verb of the simplest type:

λύω, I loose (verb-stem λυ-)

ACTIVE VOICE.

		Indicative.	Subjunctive.	Optative.	Imperative.	Infinitive.	Participle.
PRESENT.	Sing.	1. λύω, I loose	λύω	λύοιμι		λύειν	λύων, -ουσα, -ον
		2. λύεις, thou loosest	λύῃς	λύοις	λῦε		
		3. λύει, he looses	λύῃ	λύοι	λυέτω		
	Dual.	2. λύετον, ye twain loose	λύητον	λύοιτον	λύετον		
		3. λύετον they two loose	λύητον	λυοίτην	λυέτων		
	Plur.	1. λύομεν, we loose	λύωμεν	λύοιμεν			
		2. λύετε, ye loose	λύητε	λύοιτε	λύετε		
		3. λύουσι, they loose	λύωσι	λύοιεν	λυόντων		
FUTURE.		1. λύσω		λύσοιμι		λύσειν	λύσων, -ουσα, -ον
		2. λύσεις		&c., like λύοιμι			
		&c., like λύω					
IMPERFECT.	Sing.	1. ἔλυον					
		2. ἔλυες					
		3. ἔλυε					
	Dual.	2. ἐλύετον					
		3. ἐλυέτην					
	Plur.	1. ἐλύομεν					
		2. ἐλύετε					
		3. ἔλυον					
FIRST AORIST.	Sing.	1. ἔλυσα	λύσω	λύσαιμι		λῦσαι	λύσας, -ασα, -αν
		2. ἔλυσας	λύσῃς	λύσειας	λῦσον		
		3. ἔλυσε	&c., like λύω, λύῃς, &c.	λύσειε	λυσάτω		
	Dual.	2. ἐλύσατον		λύσαιτον	λύσατον		
		3. ἐλυσάτην		λυσαίτην	λυσάτων		
	Plur.	1. ἐλύσαμεν		λύσαιμεν			
		2. ἐλύσατε		λύσαιτε	λύσατε		
		3. ἔλυσαν		λύσειαν	λυσάντων		
FIRST PERFECT.	Sing.	1. λέλυκα	λελύκω	λελύκοιμι		λελυκέναι	λελυκώς, -υῖα, -ός
		2. λέλυκας	λελύκῃς	λελύκοις			
		3. λέλυκε	λελύκῃ	λελύκοι,			
	Dual.	2. λελύκατον	&c., like λύω, λύῃς	&c., like λύοιμι			
		3. λελύκατον					
	Plur.	1. λελύκαμεν					
		2. λελύκατε					
		3. λελύκασι					
PLUPERFECT.	Sing.	1. ἐλελύκη					
		2. ἐλελύκης					
		3. ἐλελύκει					
	Dual.	2. ἐλελύκετον					
		3. ἐλελυκέτην					
	Plur.	1. ἐλελύκεμεν					
		2. ἐλελύκετε					
		3. ἐλελύκεσαν					

Middle Voice.

	Indicative.	Subjunctive.	Optative.	Imperative.	Infinitive.	Participle.
PRESENT. Sing.	1. λύομαι	λύωμαι	λυοίμην		λύεσθαι	λυόμενος, -η, -ον
	2. λύει	λύῃ	λύοιο	λύου		
	3. λύεται	λύηται	λύοιτο	λυέσθω		
Dual.	2. λύεσθον	λύησθον	λύοισθον	λύεσθον		
	3. λύεσθον	λύησθον	λυοίσθην	λυέσθων		
Plur.	1. λυόμεθα	λυώμεθα	λυοίμεθα			
	2. λύεσθε	λύησθε	λύοισθε	λύεσθε		
	3. λύονται	λύωνται	λύοιντο	λυέσθων		
FUTURE.	1. λύσομαι &c., like λύομαι		λυσοίμην &c., like λυοίμην		λύσεσθαι	λυσόμενος, -η, -ον
IMPERFECT. Sing.	1. ἐλυόμην					
	2. ἐλύου					
	3. ἐλύετο					
Dual.	2. ἐλύεσθον					
	3. ἐλυέσθην					
Plur.	1. ἐλυόμεθα					
	2. ἐλύεσθε					
	3. ἐλύοντο					
FIRST AORIST. Sing.	1. ἐλυσάμην	λύσωμαι &c., like λύωμαι	λυσαίμην		λύσασθαι	
	2. ἐλύσω		λύσαιο	λῦσαι		
	3. ἐλύσατο		λύσαιτο	λυσάσθω		λυσάμενος, -η, -ον
Dual.	2. ἐλύσασθον		λύσαισθον	λύσασθον		
	3. ἐλυσάσθην		λυσαίσθην	λυσάσθων		
Plur.	1. ἐλυσάμεθα		λυσαίμεθα			
	2. ἐλύσασθε		λύσαισθε	λύσασθε		
	3. ἐλύσαντο		λύσαιντο	λυσάσθων		
FIRST PERFECT. Sing.	1. λέλυμαι	λελυμένος ὦ (-η, -ον)	λελυμένος εἴην (-η, -ον)			
	2. λέλυσαι	,, ᾖς	,, εἴης	λέλυσο	λελύσθαι	λελυμένος, -η, ον
	3. λέλυται	,, ᾖ	,, εἴη	λελύσθω		
Dual.	2. λέλυσθον	λελυμένω ἦτον	λελυμένω εἶτον	λέλυσθον		
	3. λέλυσθον	,, ἦτον	,, εἴτην	λελύσθων		
Plur.	1. λελύμεθα	λελυμένοι ὦμεν (-αι, -α)	λελυμένοι εἶμεν (-αι, α)			
	2. λέλυσθε	,, ἦτε	,, εἶτε	λέλυσθε		
	3. λέλυνται	,, ὦσι	,, εἶεν	λελύσθων		
PLUPERFECT. Sing.	1. ἐλελύμην					
	2. ἐλέλυσο					
	3. ἐλέλυτο					
Dual.	2. ἐλέλυσθον					
	3. ἐλελύσθην					
Plur.	1. ἐλελύμεθα					
	2. ἐλέλυσθε					
	3. ἐλέλυντο					
FUTURE PERFECT.	1. λελύσομαι &c., like λύομαι		λελυσοίμην &c., like λυοίμην		λελύσεσθαι	λελυσόμενος, -η, -ον

PASSIVE VOICE.

		Indicative.	Subjunctive.	Optative.	Imperative.	Infinitive.	Participle.
PRESENT.		Same as middle					
FUTURE.		” ”					
IMPERFECT.		” ”					
AORIST. Sing.	1.	ἐλύθην	λυθῶ	λυθείην			
	2.	ἐλύθης	λυθῇς	λυθείης	λύθητι	λυθῆναι	λυθείς,
	3.	ἐλύθη	λυθῇ	λυθείη	λυθήτω		-εῖσα, -έν
Dual.	2.	ἐλύθητον	λυθῆτον	λυθεῖτον	λύθητον		
	3.	ἐλυθήτην	λυθῆτον	λυθείτην	λυθήτων		
Plur.	1.	ἐλύθημεν	λυθῶμεν	λυθεῖμεν			
	2.	ἐλύθητε	λυθῆτε	λυθεῖτε	λύθητε		
	3.	ἐλύθησαν	λυθῶσι	λυθεῖεν	λυθέντων		
FUTURE.	1.	λυθήσομαι		λυθησοίμην		λυθήσεσθαι	λυθησό-
	2.	λυθήσει,		&c. like			μενος,
		&c., like λύομαι		λυοίμην			-η, -ον

VERBAL ADJECTIVES.

λυτός, λυτή, λυτόν, fit to be loosed.
λυτέος, λυτέα, λυτέον, requiring to be loosed.

Note.—The endings of second cases are as follows:—

Active and Middle.—*Second Aorist* ends like the imperfect in the indicative and like the present in the other moods.

Second Perfect ends like the first perfect.

Notes on the Tenses.—1. The future indicative active is generally formed by adding -σω to the verb-stem, *e.g.* λύ-σω. Verbs, however, whose stems end in -λ, -μ, -ν, or -ρ make their future by adding -ω to the stem and placing a circumflex accent on it, *e.g.* ἀγγέλ-λω, "I announce"; ἀγγελ-ῶ, "I will announce."

2. The commonest way of forming the aorist indicative active is by adding -α to the future stem, as in ἔλυσ-α. The stems, however, in λ, μ, ν, ρ, which do not add σ in the future, form their aorist by lengthening the last vowel of the stem and adding α. Thus μένω, "I remain," makes its future μενῶ and its aorist ἔμεινα. κρίνω similarly makes its aorist ἔκρῖνα.

This ending in -σα or -α is known as the First Aorist. Some verbs make what is known as a second aorist by adding to the verb-stem the ending -ον, which is then inflected like the imperfect, *e.g.* βάλ-λω, "I throw"; ἔβαλον, "I threw." This applies to both the active and the middle voices.

3. In the imperfect, aorist, and pluperfect tenses of the indicative the augment ἐ- is added before the verb-stem in the case of verbs which begin with a consonant; in the case of those beginning with a vowel, the vowel is lengthened according to the following table:

α and ε become η.
ι, ο, υ become ῑ, ω, ῡ.
ευ becomes ηυ.
οι becomes ῳ.
αι or ᾳ becomes ῃ.

Thus λύω makes aorist ἔλυσα, ἀγγέλλω makes aorist ἤγγειλα.

4. Some verbs have a second passive aorist which, instead of adding -θην to the stem, is formed by adding -ην, while the stem-vowel sometimes undergoes change—*e.g.* φαίνω, I show, makes its aorist passive ἐφάνην.

5. The perfect tenses are marked by reduplication, which is governed by the following rules:

i. Verbs beginning with a single consonant are reduplicated by prefixing that consonant followed by ε—*e.g.* πλέκω, I plait; πέπλεχα, I have plaited.

But an aspirate is changed to its equivalent unaspirated form—*e.g.* φεύγω, I flee; πέφευγα, I have fled.

ii. Verbs beginning with two consonants, with ζ, ξ, ψ, or ρ, have the augment ἐ- instead of reduplication—*e.g.* ζητέω, I seek; ἐζήτηκα, I have sought.

N.B.—There is an exception to this when the second of the two consonants is a liquid; in that case ordinary reduplication takes place—*e.g.* γράφω, I write; γέγραφα, I have written.

iii. In verbs beginning with a vowel reduplication takes the form of the augment.

6. There are first and second perfects just as there are first and second aorists. The first perfect ends in -κα and keeps the stem-vowel, as in λέλυ-κα.

The second perfect is formed by adding -α to the verb-stem, changing the stem-vowel, and sometimes changing a final κ, γ, π, or β into the corresponding aspirate—*e.g.* φεύγω (stem φυγ), perf. πέφευγα: κλέπτω, I steal (stem κλεπ), perf. κέκλοφα.

7. In the middle and passive voices the perfect is formed by adding -μαι to the verb-stem. When the stem ends in a consonant the following assimilation takes place:

κ and χ become γ.
β, π, and φ „ μ.
δ, θ, and τ „ ς.

Where the stem ends in a consonant the ending -νται of the 3rd person plural becomes impossible, and the periphrasis -μένοι εἰσι is used.

Contracted Vowel-Stems.—When a verb-stem ends in -ε, -α, or -ο, as in φιλέ-ω, τιμά-ω, or δηλό-ω, the vowel contracts with the person-ending. These contracted verbs form a very large class which makes familiarity with their forms essential. The following plan of conjugation of each of the three types should therefore be carefully studied:

φιλέω, I love; τῑμάω, I honour; δηλόω, I show.

INDICATIVE ACTIVE.

Present.

Sing.	1.	φιλῶ	τιμῶ	δηλῶ
	2.	φιλεῖς	τιμᾷς	δηλοῖς
	3.	φιλεῖ	τιμᾷ	δηλοῖ
Dual.	2.	φιλεῖτον	τιμᾶτον	δηλοῦτον
	3.	φιλεῖτον	τιμᾶτον	δηλοῦτον
Plur.	1.	φιλοῦμεν	τιμῶμεν	δηλοῦμεν
	2.	φιλεῖτε	τιμᾶτε	δηλοῦτε
	3.	φιλοῦσι	τιμῶσι	δηλοῦσι

Future.

φιλήσω	τιμήσω	δηλώσω
&c.	&c.	&c.

Imperfect.

ἐφίλουν	ἐτίμων	ἐδήλουν
ἐφίλεις	ἐτίμας	ἐδήλους
ἐφίλει	ἐτίμα	ἐδήλου
ἐφιλεῖτον	ἐτιμᾶτον	ἐδηλοῦτον
ἐφιλείτην	ἐτιμάτην	ἐδηλούτην
ἐφιλοῦμεν	ἐτιμῶμεν	ἐδηλοῦμεν
ἐφιλεῖτε	ἐτιμᾶτε	ἐδηλοῦτε
ἐφίλουν	ἐτίμων	ἐδήλουν

Aorist.

ἐφίλησα	ἐτίμησα	ἐδήλωσα
&c.	&c.	&c.

Perfect.

πεφίληκα	τετίμηκα	δεδήλωκα
&c.	&c.	&c.

SUBJUNCTIVE ACTIVE.

Present.

φιλῶ	τιμῶ	δηλῶ
φιλῇς	τιμᾷς	δηλοῖς
φιλῇ	τιμᾷ	δηλοῖ
φιλῆτον	τιμᾶτον	δηλῶτον
φιλῆτον	τιμᾶτον	δηλῶτον
φιλῶμεν	τιμῶμεν	δηλῶμεν
φιλῆτε	τιμᾶτε	δηλῶτε
φιλῶσι	τιμῶσι	δηλῶσι

OPTATIVE ACTIVE.

Present.

φιλοίην	τιμῴην	δηλοίην
φιλοίης	τιμῴης	δηλοίης
φιλοίη	τιμῴη	δηλοίη
φιλοῖτον	τιμῷτον	δηλοῖτον
φιλοίτην	τιμῴτην	δηλοίτην
φιλοῖμεν	τιμῷμεν	δηλοῖμεν
φιλοῖτε	τιμῷτε	δηλοῖτε
φιλοῖεν	τιμῷεν	δηλοῖεν

INDICATIVE MIDDLE.

Present.

φιλοῦμαι	τιμῶμαι	δηλοῦμαι
φιλεῖ	τιμᾷ	δηλοῖ
φιλεῖται	τιμᾶται	δηλοῦται
φιλεῖσθον	τιμᾶσθον	δηλοῦσθον
φιλεῖσθον	τιμᾶσθον	δηλοῦσθον
φιλούμεθα	τιμώμεθα	δηλούμεθα
φιλεῖσθε	τιμᾶσθε	δηλοῦσθε
φιλοῦνται	τιμῶνται	δηλοῦνται

Future.

φιλήσομαι	τιμήσομαι	δηλώσομαι
&c.	&c.	&c.

Imperfect.

ἐφιλούμην	ἐτιμώμην	ἐδηλούμην
ἐφιλοῦ	ἐτιμῶ	ἐδηλοῦ
ἐφιλεῖτο	ἐτιμᾶτο	ἐδηλοῦτο
ἐφιλεῖσθον	ἐτιμᾶσθον	ἐδηλοῦσθον
ἐφιλείσθην	ἐτιμάσθην	ἐδηλούσθην
ἐφιλούμεθα	ἐτιμώμεθα	ἐδηλούμεθα
ἐφιλεῖσθε	ἐτιμᾶσθε	ἐδηλοῦσθε
ἐφιλοῦντο	ἐτιμῶντο	ἐδηλοῦντο

Aorist.

ἐφιλησάμην	ἐτιμησάμην	ἐδηλωσάμην
&c.	&c.	&c.

Perfect.

πεφίλημαι	τετίμημαι	δεδήλωμαι
&c.	&c.	&c.

SUBJUNCTIVE MIDDLE.

Present.

φιλῶμαι.	τιμῶμαι	δηλῶμαι
φιλῇ	τιμᾷ	δηλοῖ
φιλῆται	τιμᾶται	δηλῶται
φιλῆσθον	τιμᾶσθον	δηλῶσθον
φιλῆσθον	τιμᾶσθον	δηλῶσθον
φιλώμεθα	τιμώμεθα	δηλώμεθα
φιλῆσθε	τιμᾶσθε	δηλῶσθε
φιλῶνται	τιμῶνται	δηλῶνται

OPTATIVE MIDDLE.

Present.

φιλοίμην	τιμῴμην	δηλοίμην
φιλοῖο	τιμῷο	δηλοῖο
&c.	&c.	&c.

IMPERATIVE MOOD.

Active.	Passive.	Active.	Passive.
φίλει	φιλοῦ	τίμα	τιμῶ
φιλείτω	φιλείσθω	τιμάτω	τιμάσθω
φιλεῖτον	φιλεῖσθον	τιμᾶτον	τιμᾶσθον
φιλείτων	φιλείσθων	τιμάτων	τιμάσθων
φιλεῖτε	φιλεῖσθε	τιμᾶτε	τιμᾶσθε
φιλούντων	φιλείσθων	τιμώντων	τιμάσθων

Active.	Passive.
δήλου	δηλοῦ
δηλούτω	δηλούσθω
δηλοῦτον	δηλοῦσθον
δηλούτων	δηλούσθων
δηλοῦτε	δηλοῦσθε
δηλούντων	δηλούσθων

INFINITIVE.

Active.	Passive.	Active.	Passive.
φιλεῖν	φιλεῖσθαι	τιμᾶν	τιμᾶσθαι

Active.	Passive.
δηλοῦν	δηλοῦσθαι

Verbs in -μι.—These differ from verbs in -ω only in the inflexion of the present, imperfect, and second aorist tenses, and occasionally in the perfect and pluperfect.

They fall into two classes:

(*a*) Verbs which form their present by adding the person-endings directly to the verb-stem with or without reduplication.

(In the case of reduplication the vowel used is -ι-, not -ε- as in verbs in -ω.

e.g. τί-θη-μι, I place.)

(*b*) Verbs which form their present by putting -νυ- between the verb-stem and the person-endings.

e.g. ὄμ-νυ-μι, I swear.

Note.—Most verbs in -μι have peculiarities of their own which must be learned in each case. The general scheme of their conjugation, however, is shown by the following example:

τί-θη-μι, I place (stem θε).

ACTIVE VOICE.

		Indicative.	Subjunctive.	Optative.	Imperative.	Infinitive.	Participle.
PRESENT. Sing.	1.	τίθημι	τιθῶ	τιθείην			
	2.	τίθης	τιθῇς	τιθείης	τίθει	τιθέναι	τιθείς,
	3.	τίθησι	τιθῇ	τιθείη	τιθέτω		-εῖσα, -έν
Dual.	2.	τίθετον	τιθῆτον	τιθεῖτον	τίθετον		
	3.	τίθετον	τιθῆτον	τιθείτην	τιθέτων		
Plur.	1.	τίθεμεν	τιθῶμεν	τιθεῖμεν			
	2.	τίθετε	τιθῆτε	τιθεῖτε	τίθετε		
	3.	τιθέᾱσι	τιθῶσι	τιθεῖεν	τιθέντων		
IMPERFECT. Sing.	1.	ἐτίθην					
	2.	ἐτίθεις					
	3.	ἐτίθει					
Dual.	2.	ἐτίθετον					
	3.	ἐτιθέτην					
Plur.	1.	ἐτίθεμεν					
	2.	ἐτίθετε					
	3.	ἐτίθεσαν					
SECOND AORIST. Sing.	1.	ἔθηκα (First Aorist)	θῶ	θείην		θεῖναι	θείς
	2.	ἔθηκας (First Aorist)	θῇς	&c., like τιθείην	θές		θεῖσα
	3.	ἔθηκε (First Aorist)	θῇ		θέτω		θέν
Dual.	2.	ἔθετον	θῆτον		θέτον		
	3.	ἐθέτην	θῆτον		θέτων		
Plur.	1.	ἔθεμεν	θῶμεν				
	2.	ἔθετε	θῆτε		θέτε		
	3.	ἔθεσαν, ἔθηκαν	θῶσι		θέντων		

The future θήσω and perfect τέθεικα are inflected like λύσω and λέλυκα.

Middle Voice.

Indicative.		Subjunctive.	Optative.	Imperative.	Infinitive.	Participle.
Present. Sing.	1. τίθεμαι	τιθῶμαι	τιθείμην		τίθεσθαι	τιθέμενος, -η, -ον
	2. τίθεσαι	τιθῇ	τιθεῖο	τίθεσο		
	3. τίθεται	τιθῆται	τιθεῖτο	τιθέσθω		
Dual.	2. τίθεσθον	τιθῆσθον	τιθεῖσθον	τίθεσθον		
	3. τίθεσθον	τιθῆσθον	τιθείσθην	τιθέσθων		
Plur.	1. τιθέμεθα	τιθώμεθα	τιθείμεθα			
	2. τίθεσθε	τιθῆσθε	τιθεῖσθε	τίθεσθε		
	3. τίθενται	τιθῶνται	τιθεῖντο	τιθέσθων		
Imperfect. Sing.	1. ἐτιθέμην					
	2. ἐτίθεσο					
	3. ἐτίθετο					
Dual.	2. ἐτίθεσθον					
	3. ἐτιθέσθην					
Plur.	1. ἐτιθέμεθα					
	2. ἐτίθεσθε					
	3. ἐτίθεντο					
Second Aorist. Sing.	1. ἐθέμην	θῶμαι	θείμην			
	2. ἔθου	&c., like	&c., like τιθείμην	θοῦ	θέσθαι	θέμενος, -η, -ον
	3. ἔθετο	τιθῶμαι		θέσθω		
Dual.	2. ἔθεσθον			θέσθον		
	3. ἐθέσθην			θέσθων		
Plur.	1. ἐθέμεθα					
	2. ἔθεσθε			θέσθε		
	3. ἔθεντο			θέσθων		
Perfect.	1. τέθειμαι					
	2. τέθεισαι, &c.					

Passive Voice.

Future. τεθήσομαι, τεθήσει, &c. Aorist. ἐτέθην, ἐτέθης, &c.

εἰμί, I am.

The verb εἰμί is used so much that its inflexion in full should be learned by heart; it is irregular in that it adopts forms not shown by any other of the verbs in -μι.

Indicative.		Subjunctive.	Optative.	Imperative.	Infinitive.	Participle.
Present. Sing.	1. εἰμί	ὦ	εἴην		εἶναι	ὤν, οὖσα, ὄν
	2. εἶ	ᾖς	εἴης	ἴσθι		
	3. ἐστί	ᾖ	εἴη	ἔστω		
Dual.	2. ἐστόν	ἦτον	εἶτον	ἔστον		
	3. ἐστόν	ἦτον	εἴτην	ἔστων		
Plur.	1. ἐσμέν	ὦμεν	εἶμεν			
	2. ἐστέ	ἦτε	εἶτε	ἔστε		
	3. εἰσί	ὦσι	εἶεν	ὄντων		
Imperfect. Sing.	1. ἦ, ἦν					
	2. ἦσθα					
	3. ἦν					
Dual.	2. ἦτον					
	3. ἤτην					
Plur.	1. ἦμεν					
	2. ἦτε					
	3. ἦσαν					
Future. Sing.	1. ἔσομαι		ἐσοίμην		ἔσεσθαι	ἐσόμενος, -η, -ον
	2. ἔσει		&c., like λυοίμην			
	3. ἔσται					
Dual.	2. ἔσεσθον					
	3. ἔσεσθον					
Plur.	1. ἐσόμεθα					
	2. ἔσεσθε					
	3. ἔσονται					

Defective Verbs.—The following verbs are defective, and have only the parts given below:

φημί, I say.

		Indicative.	Subjunctive.	Optative.	Imperative.	Infinitive.	Participle.
PRESENT. Sing.	1.	φημί	φῶ	φαίην		φάναι	φάς
	2.	φής	&c.	&c.	φάθι		φᾶσα
	3.	φησί					φάν
Plur.	1.	φαμέν					
	2.	φατέ					
	3.	φᾱσί					
IMPERFECT. Sing.	1.	ἔφην					
	2.	ἔφησθα					
	3.	ἔφη					
Plur.	1.	ἔφαμεν					
	2.	ἔφατε					
	3.	ἔφασαν					

δέδοικα, I fear (Perfect in Present Sense).

		Indicative.	Subjunctive.	Imperative.	Infinitive.	Participle.
PRESENT. Sing.	1.	δέδοικα, δέδια	δεδίω		δεδιέναι	δεδιώς
	2.	δέδοικας	&c.	δέδιθι		δεδιυῖα
	3.	δέδοικε, δέδιε		δεδίτω		δεδιός
Plur.	1.	δέδιμεν				
	2.	δεδοίκατε, δέδιτε		δέδιτε		
	3.	δεδοίκᾱσι, δεδίᾱσι				

PAST TENSE.—*ἐδεδοίκη, -ης, ει, ἐδέδιμεν, ἐδέδιτε, ἐδέδισαν.*

οἶδα, I know.

		Indicative.	Subjunctive.	Optative.	Imperative.	Infinitive.	Participle.
PRESENT. Sing.	1.	οἶδα	εἰδῶ	εἰδείην		εἰδέναι	εἰδώς, -υῖα, -ός
	2.	οἶσθα	εἰδῇς	εἰδείης	ἴσθι		
	3.	οἶδε	εἰδῇ	&c., like optat. of εἰμί	ἴστω		
Dual.	2.	ἴστον	&c., like subj. of εἰμί		ἴστον		
	3.	ἴστον			ἴστων		
Plur.	1.	ἴσμεν					
	2.	ἴστε			ἴστε		
	3.	ἴσᾱσι			ἴστων		
IMPERFECT. Sing.	1.	ᾔδη					
	2.	ᾔδησθα					
	3.	ᾔδει					
Dual.	2.	ᾖστον					
	3.	ᾔστην					
Plur.	1.	ᾖσμεν					
	2.	ᾖστε					
	3.	ᾖσαν					
FUTURE.	1.	εἴσομαι					
	2.	εἴσει, &c.					

ἔοικα, I am like.

Indicative.			Subjunctive.	Optative.	Infinitive.	Participle.
PRESENT. Sing.	1.	ἔοικα	ἐοίκω &c.	ἐοίκοιμι &c.	εἰκέναι	εἰκώς, -υῖα, -ός
	2.	ἔοικας				
	3.	ἔοικε				
Dual.	2.	ἐοίκατον				
	3.	ἐοίκατον				
Plur.	1.	ἔοιγμεν				
	2.	ἐοίκατε				
	3.	εἴξασι				
IMPERFECT.		ἐῴκη, &c.				
FUTURE.		εἴξω, &c.				

Irregular Verbs.—The number of verbs in Greek that are conjugated irregularly is extraordinarily large. Only experience in reading and diligent memorising can give the mastery over them. A complete list would be too large for such a work as this, but the following table of those in more common use may be of help and should be studied with great care.

The verbs are given in alphabetical order. It should be understood that those tenses not given are regularly formed.

ἀκούω, I hear.

ACTIVE.—Fut. ἀκούσομαι. Aor. ἤκουσα. Perf. ἀκήκοα.

PASSIVE.—Fut. ἀκουσθήσομαι. Aor. ἠκούσθην. Perf. ἤκουσμαι.

ἀνοίγνυμι, I open.

ACTIVE.—Fut. ἀνοίξω. Imperf. ἀνέῳγον. Aor. ἀνέῳξα. Perf. ἀνέῳχα.

PASSIVE.—Fut. ἀνοιχθήσομαι. Aor. ἀνεῴχθην. Pert. ἀνέῳγμαι.

αὐξάνω, I make to increase.

ACTIVE.—Fut. αὐξήσω. Perf. ηὔξηκα.

PASSIVE.—Fut. αυξήσομαι. Aor. ηὐξόμην, ηὐξήθην.

ἀφικνοῦμαι, I arrive.

ACTIVE.—Fut. ἀφίξομαι. Aor. ἀφῑκόμην. Perf. ἀφῖγμαι.

βαίνω, I go.

ACTIVE. — Fut. βήσομαι. Aor. ἔβην. Perf. βέβηκα.

PASSIVE.—Fut. βαθήσομαι. Aor. ἐβάθην. Perf. βέβαμαι.

βάλλω, I throw.

ACTIVE.—Fut. βαλῶ. Aor. ἔβαλον. Perf. βέβληκα.

PASSIVE.—Fut. βληθήσομαι. Aor. ἐβλήθην.

βλώσκω, I go.

ACTIVE.—Fut. μολοῦμαι. Imperf. non-existent. Aor. ἔμολον. Perf. μέμβλωκα.

βούλομαι, I wish.

ACTIVE. — Fut. βουλήσομαι. Aor. ἐβουλήθην. Perf. βεβούλημαι.

γαμῶ, I marry (of a man).

ACTIVE.—Fut. γαμῶ. Aor. ἔγημα. Perf. γεγάμηκα.

γίγνομαι, I become.

ACTIVE.—Fut. γενήσομαι. Aor. ἐγενόμην. Perf. γεγένημαι, γέγονα.

γιγνώσκω, I get to know.

ACTIVE.—Fut. γνώσομαι. Aor. ἔγνων. Perf. ἔγνωκα.

PASSIVE.—Fut. γνωσθήσομαι. Aor. ἐγνώσθην.

δέω, I bind.

ACTIVE. —Fut. δήσω. Imperf. ἔδουν. Aor. ἔδησα. Perf. δέδεκα.

MIDDLE.—Perf. δέδεμαι.

PASSIVE.—Fut. δεθήσομαι. Aor. ἐδέθην.

δέω, I lack.

ACTIVE.—Fut. δεήσω. Imperf. ἔδεον. Perf. δεδέηκα.

MIDDLE.—Aor. ἐδεήθην.

διδάσκω, I teach.

ACTIVE.—Fut. διδάξω. Perf. δεδίδαχα.

δύναμαι, I am able.

ACTIVE.—Fut. δυνήσομαι. Aor. ἐδυνήθην. Perf. δεδύνημαι.

ἐθέλω, I wish.

ACTIVE.—Fut. ἐθελήσω. Perf. ἠθέληκα.

ἐλαύνω, I drive.

ACTIVE.—Fut. ἐλῶ. Aor. ἤλασα. Perf. ἐλήλακα.

PASSIVE—Fut. ἐλαθήσομαι. Aor. ἠλάθην. Perf. ἐλήλαμαι.

ἐπίσταμαι, I know.

ACTIVE.—Fut. ἐπιστήσομαι. Aor. ἠπιστήθην. Perfect not found.

εὑρίσκω, I find.

ACTIVE.—Fut. *εὑρήσω*. Aor. *ηὗρον*. Perf. *ηὕρηκα*.
PASSIVE.—Fut. *εὑρεθήσομαι*. Aor. *ηὑρέθην*.

ἔχω, I have.

ACTIVE.—Fut. *ἕξω*, *σχήσω*. Imperf. *εἶχον*. Aor. *ἔσχον*. Perf. *ἔσχηκα*.
PASSIVE.—Aorist does not exist.

ἐῶ, I allow.

ACTIVE.—Fut. *ἐάσω*. Imperf. *εἴων*. Aor. *εἴᾱσα*. Perf. *εἴᾱκα*.

ἥδομαι, I rejoice.

ACTIVE.—Fut. *ἡσθήσομαι*. Aor. *ἥσθην*. Perf. does not exist.

κάθημαι, I sit down.

ACTIVE.—Only imperfect *ἐκαθήμην*, *καθήμην* is found.

καλῶ, I call.

ACTIVE.—Fut. *καλῶ*. Aor. *ἐκάλεσα*. Perf. *κέκληκα*.
PASSIVE.—Fut. *κληθήσομαι*, *κεκλήσομαι*. Aor. *ἐκλήθην*.

κλαίω, I weep.

ACTIVE.—Imperf. *ἔκλᾱον*. Fut. *κλαύσομαι*. Aor. *ἔκλαυσα*. No Perfect.
MIDDLE.—Perf. *κέκλαυμαι*.
PASSIVE.—Fut. *κεκλαύσομαι*. Aor. *ἐκλαύθην*.

λαγχάνω, I obtain (by lot).

ACTIVE.—Fut. *λήξομαι*. Aor. *ἔλαχον*. Perf. *εἴληχα*.
PASSIVE.—No Future. Aor. *ἐλήχθην*.

λαμβάνω, I take.

ACTIVE.—Fut. *λήψομαι*. Aor. *ἔλαβον*. Perf. *εἴληφα*.
PASSIVE.—Fut. *ληφθήσομαι*. Aor. *ἐλήφθην*.

λανθάνω, I lie hid. (*N.B.*—In middle voice = I forget.)

ACTIVE.—Fut. *λήσω*. Aor. *ἔλαθον*. Perf. *λέληθα*.

μανθάνω, I learn.

ACTIVE.—Fut. *μαθήσομαι*. Aor. *ἔμαθον*. Perf. *μεμάθηκα*.

μάχομαι, I fight.

ACTIVE.—Fut. *μαχοῦμαι*. Aor. *ἐμαχεσάμην*. Perf. *μεμάχημαι*.

μιμνήσκω, I remind.

ACTIVE.—Fut. *μνήσω*. No Perfect.
PASSIVE.—Fut. *μεμνήσομαι*, *μνησθήσομαι*. Aor. *ἐμνήσθην*. Perf. *μέμνημαι* = I remember (has Subj. *μεμνῶμαι*, Optat. *μεμνήμην*, and Imper. *μέμνησο*).

νομίζω, I think.

ACTIVE.—Fut. *νομιῶ*. Aor. *ἐνόμισα*. Perf. *νενόμικα*.
PASSIVE.—Fut. *νομισθήσομαι*, *νομιοῦμαι*. Aor. *ἐνομίσθην*. Perf. *νενόμισμαι*.

οἶμαι, I think.

ACTIVE.—Fut. *οἰήσομαι*. Imperf. *ᾤμην*. Aor. *ᾠήθην*. No Perfect.

ὄλλυμι, I destroy (rarely found uncompounded).

ACTIVE.—Fut. *ὀλῶ*. Imperf. *ὤλλυν*. Aor. *ὤλεσα*. Perf. *ὀλώλεκα*.
PASSIVE.—Aor. *ὠλόμην*. Perf. *ὄλωλα*.

ὀφείλω, I owe.

ACTIVE.—Fut. *ὀφειλήσω*. Perf. *ὠφείληκα*.
PASSIVE.—Aor. *ὠφειλήθην*. No Perfect.

πάσχω, I suffer.

ACTIVE.—Fut. *πείσομαι*. Aor. *ἔπαθον*. Perf. *πέπονθα*.

πίπτω, I fall.

ACTIVE.—Fut. *πεσοῦμαι*. Aor. *ἔπεσον*. Perf. *πέπτωκα*.

πλέω, I sail.

ACTIVE.—Fut. *πλεύσομαι*. Aor. *ἔπλευσα*. Perf. *πέπλευκα*.
PASSIVE.—Perf. *πέπλευσμαι* alone is found.

πράττω, I do.

ACTIVE.—Fut. *πράξω*. Perf. *πέπρᾱχα*, *πέπρᾱγα* (intransitive).
PASSIVE.—Aor. *ἐπράχθην*.

πυνθάνομαι, I learn of.

ACTIVE.—Fut. *πεύσομαι*. Aor. *ἐπυθόμην*. Perf. *πέπυσμαι*.

τέμνω, I cut.

ACTIVE.—Fut. *τεμῶ*. Aor. *ἔτεμον*. Perf. *τέτμηκα*.
MIDDLE.—Aor. *ἐταμόμην*.
PASSIVE.—Aor. *ἐτμήθην*.

τίκτω, I bring forth (*i.e.* give birth to).

ACTIVE.—Fut. *τέξομαι*. Aor. *ἔτεκον*. Perf. *τέτοκα*.

τιτρώσκω, I wound.

ACTIVE.—Fut. *τρώσω*. No Perfect.
PASSIVE.—Aor. *ἐτρώθην*. Perf. *τέτρωμαι*.

τυγχάνω, I hit, obtain, happen.

ACTIVE.—Fut. *τεύξομαι*. Aor. *ἔτυχον*. Perf. *τετύχηκα*.

ὑπισχνοῦμαι, I promise.

ACTIVE.—Fut. *ὑποσχήσομαι*. Aor. *ὑπεσχόμην*. Perf. *ὑπέσχημαι*.

φαίνω, I show.

ACTIVE.—Fut. *φανῶ*. Aor. *ἔφηνα*. Perf. *πέφαγκα*.
PASSIVE.—Fut. *φανοῦμαι*, *φανήσομαι*. Aor. *ἐφάνην*. Perf. *πέφηνα*.

φθείρω, I destroy.

ACTIVE.—Fut. *φθερῶ*. Aor. *ἔφθειρα*. Perf. *ἔφθαρκα*, *ἔφθορα*.
PASSIVE.—Fut. *φθεροῦμαι*, *φθαρήσομαι*. Aor. *ἐφθάρην*. Perf. *ἔφθαρμαι*.

χαίρω, I rejoice.

ACTIVE.—Fut. *χαιρήσω*. Aor. *ἐχάρην*. Perf. *κεχάρηκα*.

χρή, there is need of (impersonal).

Fut. χρῆσται. Imperf. ἐχρῆν. Pres. Subj. χρῇ. Optat. χρείη. Infin. χρῆναι. Partic. χρέων. No other parts exist.

Verbs Inflected by means of Different Roots.—The most perplexing class of Greek verbs consists of a few in common use which form different tenses from different roots. The most important are given below in alphabetical order:

ἀγορεύω, I say.

Pres. ἀγορεύω. Fut. ἐρῶ. Aor. εἶπον, εἶπας, εἶπε, εἴπατον, εἰπάτην, εἴπομεν, εἴπατε, εἶπον. Perf. εἴρηκα. Aor. Pass. ἐρρήθην. Fut. Pass. εἰρήσομαι, ῥηθήσομαι.

αἱρῶ, I take.

Pres. αἱρῶ. Fut. αἱρήσω. Imperf. ᾕρουν. Aor. εἷλον. Perf. ᾕρηκα. Pres. Pass. ἁλίσκομαι. Imperf. Pass. ἡλισκόμην. Fut. Pass. ἁλώσομαι. Aor. Pass. ἑάλων, ἡρέθην. Perf. Pass. ἑάλωκα, ᾕρημαι.

ἔρχομαι, I go.

Pres. Indic. ἔρχομαι. Pres. Subj. ἴω. Pres. Optat. ἴοιμι. Pres. Imper. ἴθι, ἴτω, ἴτον, ἴτων, ἴτε, ἰόντων. Pres. Infin. ἰέναι. Pres. Part. ἰών. Imperf. ᾖα, ᾔεισθα, ᾔει, ᾖτον, ᾔτην, ᾖμεν, ᾖτε, ᾖσαν. Fut. εἶμι, εἶ, εἶσι, ἴτον, ἴτον, ἴμεν, ἴτε, ἴασι. Aor. Indic. ἦλθον. Aor. Subj. ἔλθω, &c. Perf. ἐλήλυθα, ἥκω. Pluperf. εἰληλύθη, ἧκον.

ἐσθίω, I eat.

Pres. ἐσθίω. Fut. ἔδομαι. Imperf. ἤσθιον. Aor. ἔφαγον. Perf. ἐδήδοκα. Pass. Perf. ἐδήδεσμαι. Pass. Aor. κατεδέσθην.

ζῶ, I live.

Pres. Indic. ζῶ. Subj. ζῶ. Optat. ζῴην. Imperat. ζῆ. Infin. ζῆν. Part. ζῶν. Imperf. ἔζων. Fut. βιώσομαι, ζήσω. Aor. ἐβίων. Perf. βεβίωκα.

κτείνω, I kill.

Fut. κτενῶ. Aor. ἔκτεινα. Perf. ἀπέκτονα. For the Passive is used ἀποθνήσκω. Fut. ἀποθανοῦμαι. Aor. ἀπέθανον. Perf. τέθνηκα.

ὁρῶ, I see.

Imperf. ἑώρων. Fut. ὄψομαι. Aor. εἶδον (Subj. ἴδω, Optat. ἴδοιμι, &c. &c.). Perf. ἑόρᾱκα, ὄπωπα. Pass. Aor. ὤφθην. Pass. Fut. ὀφθήσομαι.

τρέχω, I run.

Fut. θρέξομαι, δραμοῦμαι, θεύσομαι. Imperf. ἔθεον, ἔτρεχον. Aor. ἔδραμον. Perf. δεδράμημαι.

φέρω, I bear.

Fut. οἴσω. Aor. ἤνεγκ-ον, -ας, -ε, -ατον, -ατην, -αμεν, -ατε, -ον. Perf. ἐνήνοχα. Pass. Aor. ἠνέχθην.

ὠνοῦμαι, I buy.

Has Aor. ἐπριάμην.

Prepositions.—The only part of speech remaining that may present any difficulty is the *Preposition*. In Greek, prepositions govern some the Accusative, some the Genitive, and some the Dative case, *i.e.* the noun depending on them falls into one of those cases—*e.g.*

πλέων εἰς τὰς Ἀθήνας, sailing to Athens.
ἀπ' ἐκείνης τῆς ἡμέρας, from that day.

The following prepositions govern the accusative:

εἰς, to ἀνά, up

The following govern the genitive:

ἀντί, instead of. ἀπό, from.
ἐκ (ἐξ before vowels), out of. πρό, before.

The following govern the dative:

ἐν, in. σύν (in poetry sometimes ξύν), with.

The following govern the accusative or genitive, according to meaning:

	Accusative.	Genitive.
διά	on account of	through
κατά	at, by	down from, down over
ὑπέρ	beyond	over, for the sake of
μετά	after	with

The following govern the accusative, genitive, or dative, according to meaning:

	Accusative.	Genitive.	Dative.
ἀμφί	around.	about.	*of Place:* round about. *not of Place:* on account of, concerning.
ἐπί	*of Place:* extending over, towards, in quest of. *of Time:* for a certain time, until.	*of Place:* upon, by, at, towards. *of Time:* in the course of. *with Pers. Pronoun:* ἐφ' ἑαυτοῦ = by himself. *of Persons:* in the presence of, in the time of.	*of Place:* on, over against. *of Time:* at, on. *of Persons:* in the power of, with a view to, upon a condition.
παρά	*of Place:* past. *of Time:* during. *of Persons:* to the presence of. *of Things:* contrary to.	from the side of.	by the side of.

	Accusative.	Genitive.	Dative.
περὶ	*of Place:* round. *of Time:* about.	*of Things:* about.	*of Place:* about. *of the object of an action:* for. *of a cause:* by reason of.
πρὸς	*of Place:* towards. *of Time:* getting on for. *Generally of relation:* in regard to, according to, in proportion to. *in adversative sense:* against.	*of Direction:* towards. *in oaths:* by, *e.g.* πρὸς τῶν σῶν γονάτων = by your knees (I adjure you).	in addition to. *of Place:* at.
ὑπό	*of Place:* under, *i.e.* motion under. *of Time:* *e.g.* ὑπὸ νύκτα = at nightfall.	*of Place:* beneath. *of the agent:* by.	*of Place:* under, *i.e.* position under, subject to.

Exercise.—In the following exercise care should be taken to ascertain all the possible meanings of each word before passing on to the next.

Translate:

(1) *ὁ τῶν Περσῶν βασιλεὺς ἐμάχεσατο πρὸς τοὺς Ἀθηναίους.* (2) *αἱ μὲν γυναῖκες ἥδοντο, οἱ δ' ἄνδρες ἐβαρύνοντο.* (3) *ἀγαθὸς ἀνὴρ ὑπὸ παντῶν τῶν σοφῶν φιλητέος ἐστίν.* (4) *ἀνήρ τις ἀπὸ Κορίνθου.* (5) *τίς πάρεστιν;* (6) *αὐτὸς ὁ ἄρχων ἄφικται.* (7) *ἀνοίγνυ ταύτην τὴν θύραν.* (8) *τίς οὐκ οἶδε ταῦτα;* (9) *ἡ γεωμετρία ηὑρέθη ὑπὸ τοῦ Εὐκλείδους.* (10) *ἡδύ ἐστι τὸ φιλεῖσθαι.* (11) *οὐκ ἐδυνήθησαν παρελθεῖν.* (12) *δὸς μοὶ δύο ὀβόλους.* (13) *ἐπορεύου διὰ τῆς τῶν πολεμίων χώρας.* (14) *πρὸ τούτου τοῦ πολέμου οἱ Λακεδαιμόνιοι εὐδαίμονες ἦσαν.* (15) *μετὰ ταῦτα ὁ Θεμιστόκλης πολλὰ εἰπεῖν ἐπειρήσατο, οἱ δὲ Λακεδαιμόνιοι οὐκ ἐβούλοντο ἀκούειν.* (16) *αὐτὸς ὁ Κύρος πάρεισιν.* (17) *ὁ αὐτὸς ἄγγελος ἦλθεν ἀπὸ τοῦ Φιλίππου.* (18) *καίπερ ὀλιγοὶ ὄντες οὐ νικηθήσονται οἱ Ἀθήναιοι ἐν τοιαύτῃ μάχῃ.* (19) *αἱ μὲν Μοῦσαι ἔννεα εἰσίν, αἱ δὲ Χάριτες τρεῖς.* (20) *ποῦ ἐστὶν ὁ τούτων τῶν δούλων δεσπότης;*

Accents

There are in Greek three accents—*acute* (ˊ), *grave* (ˋ), and *circumflex* (ˆ). These represent variations of pitch in the language as originally spoken: the grave accent really indicates that the syllable on which it appears was unaccented.

The following technical adjectives are applied to words accented in different ways:

Oxytone—acute on last syllable.
Paroxytone—acute on last syllable but one.
Proparoxytone—acute on last syllable but two.
Perispomenon—circumflex on last syllable.
Properispomenon—circumflex on last syllable but one.
Barytone—grave or no accent on last syllable.

The rules for accentation are:

1. The last syllable but two can only bear an acute accent, and that only when the last syllable is short.

e.g. ἄριστος, but ἀρίστοις.

2. The last but one, if accented, takes the circumflex if it is long and the following syllable is short; otherwise acute.

e.g. νῆσος, but νήσοις.

For the purpose of these rules genitives in -εως, -εων, from nouns in -ις, -υς, are counted as short; similarly with final -αι, -οι.

e.g. ἄνθρωποι, πόλεως.

3. An oxytone word becomes barytone when followed by an accented word in the same sentence.

e.g. λαγώς, but λαγὼς τῆς Ἀρτέμιδος.

4. In the 1st Declension the gen. plur. is always perispomenon.

e.g. χώρα, but χωρῶν.

5. In the 1st and 2nd Declensions the last syllable of the gen. and dat. of oxytone words takes the circumflex.

e.g. τιμή, but τιμῇ.
ὁδός, but ὁδοῖς.

6. In the 3rd Declension words of one syllable place a circumflex on the ending of the gen. plur.

e.g. ναῦς, but νεῶν.

παῖς, πᾶς, οὖς, and a few other monosyllables are exceptions to this rule.

e.g. παῖς, παίδων.

7. Verbs are accented on the farthest syllable from the end which rules 1 and 2 allow.

e.g. ἐπιμαρτύρομαι, διώκω, &c.

But:

(*a*) Participles are accented as nouns.

(*b*) The weak aorist infinitive active, strong aorist infinitive middle, perfect infinitive and participle passive, and all infinitives in *-ναι*, have the accent on the last syllable but one.

e.g. *μαρτυρῆσαι, γενέσθαι, λελύσθαι, λελυμένος, πεποιῆναι.*

(*c*) The strong aorist participle active, participles in *-εις, -ους, -υς,* and *-ως*, and the present participle active of verbs in *-μι*, are oxytone.

e.g. *εἰπών, τιθείς, λυθείς, διδούς, λελυκώς*, &c.

(*d*) Strong aorist infinitives active in *-ειν*, and the 2nd pers. sing. of strong aorist imperatives middle in *-ου*, are perispomenon.

e.g. *εἰπεῖν, γενοῦ.*

But in the second case, if the verb is compounded with a preposition of two syllables, the rule does not apply.

e.g. *ἀπό-δου.*

8. Before an enclitic (a word that has no accent) the following takes place:

(*a*) Proparoxytone words add an acute on the last syllable.
(*b*) Properispomenon words do the same.
(*c*) Oxytone words retain the acute accent.
(*d*) Paroxytone words remain as they are—*e.g.* *κατήγορός τις, νῆσός τις, καλός τις, χώρα τις.*

Note.—Most of the above rules are subject to some exceptions which must be learned by experience.

Syntax, or the Use of Words

Syntax is the science of the use of words in sentences. Sentences are either *Simple* or *Compound.*

A Simple Sentence has two parts:

1. The *Subject*—the person or thing about which something is stated.
2. The *Predicate*—that which is stated about the subject.

Thus, in the sentence *ὁ Πελοπίδας ἐνίκησε τοὺς Ἀθηναίους*, "Pelopidas defeated the Athenians," *ὁ Πελοπίδας* is the subject and *ἐνίκησε τοὺς Ἀθηναίους* is the predicate.

The subject must be one of the following:

1. A *Substantive*: *ὁ βασιλεύς*, the king.
2. A *Substantive Pronoun*: *ὑμεῖς*, you.
3. An *Adjective, Participle*, or *Adjective Pronoun*: *ἐκεῖνος*, that man.
4. A *Verb Noun*: *τὸ φιλεῖσθαι ἡδύ ἐστιν*, to be loved is sweet.

Note.—A Personal Pronoun as subject is usually implied in the verb and is not separately expressed: *e.g.* *φημί*, I say. But for the purpose of emphasis the pronoun may be expressed: *e.g.* *ἐγὼ μὲν βούλομαι λέγειν, σὺ δ' οὐκ ἐθέλεις ἀκούειν*, I wish to speak, but you are not willing to listen.

The *Predicate* must be a verb or a group of words containing and centring round a verb.

e.g. *ὁ Ἀλκιβιάδης ἀπῆλθεν*, "Alcibiades went away"—*ἀπῆλθεν* is predicate.
ὁ ἄρχων ἐπαινεῖ τὸν ῥήτορα ὅνπερ νομίζει πάντων εἶναι σοφώτατον, "the archon praises the orator whom he thinks the wisest of all"—from *ἐπαινεῖ* to *σοφώτατον* is predicate.

Agreement.—Adjectives, participles, and articles agree with their nouns in number, gender, and case.

Pronouns agree with their antecedents in number and gender, except that a relative pronoun, the object of a verb, is generally attracted into the case of its antecedent.

e.g. *μητὴρ ἀνδρῶν ὧν εἶδον*, the mother of the men I saw.

Verbs agree with their subject in number, gender, and person, except that a subject in the neuter plural is followed by a verb in the singular.

e.g. *ταῦτα δεινά ἐστιν*, these things are dreadful.

A noun agrees in number, and where possible in gender, with a noun to which it is in apposition. After *εἰμί* or a similar verb it agrees in number and case with a noun of which it is predicative.

The Article.—The article *ὁ, ἡ, τό* corresponds generally to the English "the."

Originally it played the part of a personal pronoun. Traces of this usage survive in such phrases as *ὁ μέν . . . ὁ δέ*, the one . . . the other; *οἱ μέν . . . οἱ δέ*, some . . . others; or in the use of *ὁ δέ* at the beginning of a sentence = he, referring to a person already mentioned and indicating a new subject of the sentence.

e.g. *ταῦτα ἤγγειλε τῇ γυναικί, ἡ δὲ χαλεπῶς ἤνεγκεν*, he announced this to the woman and she was vexed.

The ordinary use of the article is to point out something definite, that is known to the speaker or has been mentioned before, just as the word "the" is used in English.

e.g. *ὁ τῶν βαρβάρων ἄναξ*, the king of the barbarians.

Note, therefore, the difference of meaning between *πολλοὶ τοῦτο ποιοῦσιν*, "many men do this," and *οἱ πολλοὶ τοῦτο ποιοῦσιν*, "the common herd do this."

Greek uses the article also where it is discarded in English in the following instances:

1. With *abstract* nouns: *ἡ ἀρετή* = virtue.
2. With *proper names*: *ὁ Πίνδαρος* = Pindar.
3. With nouns spoken of as a class: *οἱ κύνες εὐνούστεροι εἰσὶ τοῖς ἀνθρώποις ἢ οἱ λύκοι*, dogs are more friendly to men than wolves.

When a noun with the article is qualified by an adjective, the adjective is usually placed between the noun and the article.

e.g. *ὁ πρῶτος ἀνήρ*, the first man.

Occasionally it comes after the noun, in which case the article is repeated.

e.g. *ἡ γυνὴ ἡ καλή*, the beautiful woman.

When the adjective appears in any other position, its meaning is not qualifying, but predicative.

e.g. *ἡ κόρη καλὴ ἐγένετο*, the girl became beautiful.

The article is also used in Greek where English would employ a possessive pronoun (*e.g.* my, his, our), wherever the context leaves no room for doubt as to the meaning.

e.g. *ὁ Οἰδίπους ἀπέκτεινε τὸν πατέρα*, Œdipus killed his father.

The article is often used without any noun qualified by it in adjectival phrases.

e.g. *οἱ περὶ τὸν Σωκράτην*, those about Socrates.
οἱ ἐν τῇ πόλει, the men in the city.

Another very common and idiomatic use is with participles to denote a group of persons or things, where English would use a demonstrative pronoun followed by a relative.

e.g. *οἱ τὴν ἀλήθειαν φιλοῦντες*, those who love truth.

Translate, giving every possible meaning of:

(1) *οἱ μὲν τῶν ἀνθρώπων φιλοῦσι τὸ πολεμεῖν, οἱ δ' ἀπεχθαίρουσιν.* (2) *πολλοὶ μὲν ἐβούλοντο σώζειν τὸν Σωκράτην, ὁ δ' οὐκ ἤθελεν.* (3) *αὕτη ἡ ἡμέρα μεγάλων ἦν ἀρχὴ κακῶν τοῖς Ἀθηναίοις.* (4) *τῇ αὐτῇ ἡμέρᾳ οἱ πολέμιοι ἀπῆλθον.* (5) *ἡ σωφροσύνη, ἡ πασῶν τῶν ἀρετῶν μεγίστη.* (6) *τίς ἀνδρῶν οὐ φιλεῖ τὴν μητέρα;* (7) *οἱ εὖ διάγοντες ἀεὶ σεβίζουσι τοὺς θεούς.* (8) *τὸ μὲν ἐσθίειν χρήσιμον, τὸ δὲ πλέον ἐσθίειν αἰσχρόν ἐστιν.* (9) *αἱ οἶες ἀεὶ φοβοῦνται τοὺς κύνας.* (10) *ἡ σχολὴ ἡδεῖα ἐστι τοῖς δούλοις τοῖς σφόδρα κεκμηκόσιν.* (11) *ὁ Δημοσθένης, ὁ τῶν ῥητόρων δοκιμώτατος, πάντας τοὺς Ἀθηναίους ἐνίκα ἐν τῷ εὐρύθμως λέγειν.* (12) *τοὺς μὲν ἐν τῇ πόλει ηὗρον τοὺς δ' οὔ.* (13) *ὁ ἄνθρωπος θνητός ἐστιν.*

Pronouns.—*Possessive*: The pronouns that indicate possession are: *ἐμός*, mine; *σός*, thine; *ἡμέτερος*, our; and *ὑμέτερος*, your.

(In the case of the 3rd person, Greek has no possessive pronouns to convey the meaning of *his, her, its, their*. In their stead is used the genitive of the demonstrative pronoun, viz. *ἐκείνου, ἐκείνης, ἐκείνων*.)

When the possessor to whom the pronoun refers is the subject of the sentence, the article alone is used without any pronoun.

e.g. *ὁ Οἰδίπους ἀπέκτεινε τὸν πατέρα*, Œdipus killed his father.

When, however, emphasis is laid on the relationship of possessor and possessed, the pronoun is used even when referring to the subject.

e.g. *τὴν σὴν μητέρα οὐ τιμᾶτε*, you do not honour your own mother.

Note.—The possessive pronouns are never used without the article preceding them. Thus *ὁ ἐμὸς πατήρ* or *ὁ πατὴρ ὁ ἐμός* = "my father," but never *ἐμὸς πατήρ* or *πατὴρ ἐμός* except in poetry.

If it is desired to use particular emphasis, the genitive of the reflexive pronoun is used instead of the possessive.

e.g. *πῶς ἂν δυναίμην τὴν ἐμαυτοῦ μητέρα ἀτιμάζειν;* how could I insult my own mother?

When the person or thing that is the possessor is other than the subject of the sentence, then the possessive pronouns or the genitive of the personal pronouns are used. Thus "I saw your brother" can be translated *εἶδον τὸν σὸν ἄδελφον*, or *εἶδον τὸν σοῦ ἄδελφον*.

There is a distinct and idiomatic use of the possessive pronouns by which they are sometimes used to indicate dependence on rather than possession of the noun to which they refer. Thus *αἱ ἐμαὶ διαβολαί* can mean "my slanders"—*i.e.* uttered by me—or "the slanders against me." Similarly *δωρεὰ ἐμή* can mean "a gift made by me" or "a gift to me."

Reflexive.—Reflexive pronouns are those which are used when the subject of the sentence is referred to.

e.g. *γνῶθι σεαυτόν*, know thyself.

They are: *ἐμαυτόν*, myself; *σεαυτόν*, thyself; *ἑαυτόν*, him-, her-, or itself; *ἡμᾶς αὐτούς*, ourselves; *ὑμᾶς αὐτούς*, yourselves; *ἑαυτούς*, themselves.

These are used when the meaning is direct.

e.g. *σεαυτὸν διολώλεκας*, you have destroyed yourself.

In Greek a fine distinction was sometimes drawn between such a reflexive meaning and the case where the pronoun refers not to the immediate subject of the verb that governs it, but to the more distant subject of the whole sentence. In that case the forms *ἕ, οὗ, οἷ* in

the singular and σφᾶς, σφῶν, σφίσιν in the plural are used.

e.g. ἐκέλευσε τὸν οἰκέτην τὴν οὗ μητέρα περιμένειν, he bade the servant wait for his (the bidder's) mother.

This usage is more common in poetry than in prose.

Relative.—There are three chief relative pronouns: ὅς, ὅσπερ, which are definite; ὅστις, which is indefinite.

ὅς is the most general in meaning.

e.g. ἀνὴρ ὃν τιμᾷ ὁ βασιλεύς, the man whom the king honours.

ὅσπερ is more precise.

e.g. ἀνὴρ ὅνπερ εἶδον, the very man I saw.

ὅστις is the least precise, and refers to a class of persons or things.

e.g. εὐδαίμων ἐστιν ὅστις τοὺς θεοὺς σεβίζει, happy is he who reveres the gods.

Some phrases formed round the relative pronoun have become crystallised and are equivalent to pronouns.

e.g. ἔστιν οἵ (which is declined throughout) = some.
ἔστιν ὅστις; (also declined) = is anyone?
οὐδεὶς ὅστις οὐ = everyone (*lit.* nobody who not).

Generally speaking, the relative pronoun agrees with the noun it represents (called the antecedent) in number and gender, and takes whatever case is required by its position in its own clause. But there is a common idiom by which, when the relative would naturally be in the accusative case, it is attracted into the genitive or dative of its antecedent.

e.g. στρατιὰν ἦγεν ἀπὸ τῶν πόλεων ὧν ἔπεισε, he was leading an army from the cities that he persuaded.
οὐδὲν ὧν λέγω (ἐκείνων being understood after οὐδέν), nothing of what I say.

If the antecedent is a substantive it often transfers to the relative clause.

e.g. ἐπιλέλησται ὧν πρότερον ἐφίλει ἑταίρων, he has forgotten the companions he used to love.

Note.—The relative is never omitted in Greek as it is sometimes in English. Thus "the man I saw" is always ἀνὴρ ὃν εἶδον.

αὐτός.

αὐτός cannot be placed under one head, as it is used in various senses as follows:

1. In the nominative case:

(*a*) In an *intensive* sense = self.

e.g. ὁ στράτηγος αὐτὸς ἀφίκετο / αὐτὸς ὁ στράτηγος ἀφίκετο } the general himself came.
αὐτὸς τοῦτο ἔφην, I myself said this.

It is used in this sense in the idiom: αὐτὸς τρίτος ἐστρατήγει, he was general with two others (*lit.* himself the third).

(*b*) Meaning "same," preceded by the article: ὁ αὐτὸς δοῦλος, the same slave.

2. In the other cases:

(*a*) As the pronoun of the 3rd person: ἔπεμψα αὐτήν, I sent her.
(*b*) When first word in the sentence, meaning "self": αὐτοῦ ἤκουσα λέγοντος, I heard him speak himself.
(*c*) When followed by a personal pronoun, meaning "self": εἶδον αὐτοὺς ὑμᾶς, I saw you yourselves.
(*d*) Preceded by the article, meaning "same": εἶδον τὸν αὐτὸν δοῦλον, I saw the same slave.

A very idiomatic use is with the dative of a substantive to denote accompaniment.

e.g. ἡ πόλις ᾑρέθη αὐτοῖς ἀνδράσιν, the city was taken, garrison and all.

Translate, giving every possible meaning of:

(1) τὸν μὲν ἄρχοντα οὐκ εἶδεν, τὴν δ' αὐτοῦ γυναῖκα πρόσειπεν. (2) ἡ Μήδεια λέγεται τὸν ἄδελφον στύγησαι. (3) ὦ γύναι, τὸν σὸν ἄδελφον οὐ φιλῶ. (4) ὦ Μήδεια, πῶς δυνήσει τὸν σαυτῆς ἄδελφον ἀποκτείνειν; (5) ὁ βασιλεὺς μεγὰ δῶρον ἔδωκε τῷ ὑμῶν πατρί. (6) οὐ σὸν τόδ' ἐστι τοὔργον. (7) ὁ σὸς πόθος. (8) οὐ ῥᾳδίως ἐμαυτὸν τραυματίσω. (9) ἠρώτησεν αὐτοὺς εἰ βούλονταί ἑ ἀποκτεῖναι. (10) ἀφίκετο σὺν ὧνπερ εἶχεν οἰκετῶν. (11) οὐδεὶς γάρ ἐστιν ὅστις οὐκ οἶδεν τόδε. (12) ἐκεινός ἐστιν ὅνπερ εἶδον ἐν τῇ ὁδῷ. (13) ἀλλ' ἔστιν αἱ γυναῖκες οὐ φιλοῦσι τὸ τίκτειν. (14) αὐτῇ σὺν φόρμιγγι ἀνόρουσεν. (15) οὐ δυνάμεθα ταὐτὸ αὖθις πράττειν. (16) αὐτὸ τὸ ἔργον δείξει. (17) αὐτὸ τὸ περίορθρον πάρεστιν. (18) οὔ μοι μέλει ἄλγος αὐτῆς τῆς Ἑκαβῆς.

Demonstrative.—The demonstrative pronouns οὗτος, ὅδε, "this," and ἐκεῖνος, "that," are used in two ways:

1. As adjectives, in which case their position is predicative, *i.e.* without the article:

e.g. οὗτος ὁ ἀνήρ, this man.
ἡ γυνὴ ἐκείνη, that woman.

2. As pure pronouns:

e.g. οὗτοι ἦσαν ἐν τῇ μάχῃ, these men were in the battle.
λέγει τάδε, he speaks as follows.

Indefinite.—The indefinite pronoun τις and the interrogative τίς similarly may be used:

1. Adjectively.

e.g. ἀνήρ τις ἐμοὶ ταῦτα εἶπεν, some man told me this,

2. Pronominally.

τῶν στρατιωτῶν τινες ἔκαμνον, some of the soldiers were weary.

N.B.—The indefinite *τις* can never be the first word in the sentence.

The Cases. *Nominative.*—The case of the Name. The subject of the sentence is in the nominative case.

οἱ Λακεδαιμόνιοι ἀπῆλθον, the Lacedaemonians departed.

The nominative is also the case of the complement after *εἰμί,* "I am," *γίγνομαι,* "I become," and verbs of similar meaning, and also after the passive of such verbs as *καλῶ,* "I call."

e.g. ἡ κορὴ γέγονε γυνή, the girl has become a woman.

ὁ Σόλων ὁ σοφὸς ἐκαλεῖτο, Solon was called "the wise."

There are some verbs with the meaning of "perceive" or some similar meaning that are constructed with the accusative of a participle. The nominative of the participle is used, however, when the subject of the participle is the same as that of the main verb.

e.g. αἰσθάνομαι ὑπὸ πάντων μισούμενος, I perceive that I am hated by all.

Vocative.—The case of Address.

The vocative, or nominative used as vocative, stands isolated from the rest of the sentence without any place in its construction. In Greek it is usually accompanied by the exclamation *ὦ.*

e.g. τί δρᾷς, ὦ γέρον; what are you doing, old man?

Accusative.—The accusative expresses three main ideas:

1. Direct Object.
2. Limitations of Time and Space.
3. Adverbial Relations.

I. *Direct Object.*—The direct object of a transitive verb is in the accusative case.

οἱ Συρακόσιοι δύο τροπαῖα ἔστησαν, the Syracusans erected two trophies.

Verbs of *making, naming, thinking,* &c., have a second accusative agreeing with the object.

τὴν πόλιν Θήβας ὀνομάζουσι, they call the city Thebes.

Some verbs of *saying* and *thinking* may have as their object an accusative followed by an infinitive of which it is the subject.

e.g. ἔφη τὸν βασιλέα μὴ εἰδέναι τάδε, he said the king did not know this (*lit.* he said the king not to know this).

A similar construction is found with impersonal verbs.

δεῖ σε μανθάνειν, you ought to learn.

Some verbs, not properly transitive, may be used transitively.

e.g. θαρρῶ τὸν θάνατον, I have no fear of (*lit.* I am brave) death.

Verbs of *asking, concealing, teaching, clothing, depriving,* &c., take two accusatives, one of the person, the other of the thing.

τοῦτο μόνον αἰτῶ ὑμᾶς, this one thing I ask you.

μή με κρύψῃς τοῦτο, keep not this hid from me.

Intransitive verbs sometimes take as object an accusative noun with meaning similar to their own.

νόσον νοσεῖν, to be ill of a disease.
ἀγῶνα τρέχειν, to run a heat.

II. *Time and Space.*

1. *Motion towards* a thing or place.
   The accusative is used in prose with a preposition. In poetry the preposition is sometimes omitted.

ἀγγέλους ἔστειλαν ἐς τὰς ἄλλας πόλεις, they sent messengers to the other cities.

2. *Duration of Time.*

τέσσαρα καὶ δέκα ἔτη ἐνέμειναν αἱ σπονδαί, the truce lasted fourteen years.

3. *Extent of Space.*
   δέκα πόδας ἀπῆν, he was ten feet away.

III. *Adverbial Relations.*

1. *Accusative of Respect*—*i.e.* accusative of the thing in respect of which one looks or feels somehow.

e.g. ἀλγῶ τὴν κεφαλήν, I have a headache.
ἐτραυματίσθη τὸ στῆθος, he was wounded in the breast.

2. *Adverbial* accusative neuter of pronouns or adjectives.

τὸ λοιπὸν οὐκ ἐάσω ταῦτα, for the future I will not allow this.

Hence the many adverbs which are really neuter accusatives.

e.g. πολύ, πλέον, &c.

3. Under this head may be placed the *Absolute* use of the accusative neuter singular of the participles of impersonal verbs.

e.g. ἔξον μένειν οὐκ ἀπελεύσομαι, it being permitted to remain, I will not go away.

4. *In Oaths.*
   νὴ τὸν Δία, by Zeus!

Translate, giving every possible meaning of: (1) *ἔπεμψαν πέντε ναῦς ἐς τὴν Πύλον.* (2) *οἱ ἐν τῇ μάχῃ νενικημένοι ἀνεχώρησαν ὑπὸ τὸ τεῖχος.* (3) *τεῖχος περιεβάλετο τὴν πόλιν.* (4) *πόσον χρόνον ἔμεινας ἐν τῇ νήσῳ;* (5) *περιεδέθη*

τὰς χεῖρας. (6) ὡς μακρὸν ἔζηκας βίον. (7) ἔφη τὸν Σωκράτην μὴ σεβίζειν τοὺς θεούς. (8) οὐ χρὴ τοὺς ἀνθρώπους φιλεῖν τὸ πολεμεῖν. (9) οἱ Θήβαιοι ἱπποσύνας ἐδίδαξαν τοὺς Ἀθηναίους. (10) αὕτη ἡ κώμη δώδεκα σταδίους ἀπέχει. (11) ὕστερον ἐς Μεθώνην ἀφίκοντο. (12) μὰ τὸν Ἀπόλλωνα, τοιαῦτα οὐ πείσομαι. (13) εἰς τοιοῦτον ἄνδρα τίς δύναται ὑβρίζειν, δέον μᾶλλον τιμᾶν αὐτόν; (14) νόσον νοσεῖς ἣν οὐδαμῶς κρύψεις τὴν μητέρα. (15) οἱ δ' Ἀθήναιοι ἔπλευσαν αὐθημερὸν ἐς Κρομμυῶνα· ἀπέχει δὲ τῆς Κορινθίας εἴκοσι καὶ ἑκατον σταδίους. (16) δεῖ ἡμᾶς τὸν τῆς Χερσονήσου ἰσθμὸν τειχίζειν.

The Genitive.—The genitive is the case which, speaking generally, translates the English word "of."

Its chief uses fall under two heads—*Connection*, and *Separation or Origin*.

I. *Connection.*

1. *Genitive of Possession.*

(*a*) *Objective.* (*b*) *Subjective.*

Thus ἑταίρων φιλία may mean "affection of friends" or "affection for friends."

2. *Material.*

δύο τάλαντα ἀργυρίου, two talents of silver.

3. *Partitive Genitive*—*i.e.* the genitive of a whole of which a part or parts are distinguished.

τῶν στρατιωτῶν τινές, some of the soldiers.
αἱ ἡμίσειαι τῶν νεῶν, half the ships.

Akin to this is the use of the genitive after words meaning *to share*, &c.

οὐ βούλονται τῆς δαιτὸς μεταλαμβάνειν, they do not wish to share the feast.

4. *Describing Genitive.*

παῖς πέντε ἐτῶν, a boy five years old.
τριῶν ἡμερῶν ὁδός, a three-days' journey.

Akin to this meaning is the use of the genitive after verbs meaning *to condemn, try, acquit*, &c., defining the offence.

e.g. κατηγόρωσεν αὐτὸν ἀσεβείας, he denounced him for impiety.

5. Under this head may be placed the use of the genitive after verbs and adjectives implying *sharing, remembering, touching, tasting, aiming at, governing*, &c.

ἐπιλέληθε τῶν ὀφειλῶν, he forgot his debts.
οἱ Λακεδαιμόνιοι ἦρξαν τοῦ πολέμου, the Lacedaemonians began the war.
ἥψατο τῶν τοῦ στρατηγοῦ γονάτων, he clung to the general's knees.

6. *Genitive of Price.*

δῶρον πολλοῦ ἄξιον, a gift of great value.
πόσου ἐπράθη ὁ βοῦς; for how much was the ox sold?
ἐπριάμην αὐτὸν πέντε μνῶν, I bought it for five minas.

7. *Time within which.*

τρὶς τῆς ἡμέρας, three times a day.

8. *Genitive Absolute.*—This is a phrase consisting of a noun and a participle in the genitive case. It is independent of the construction of the rest of the sentence; hence the name *Absolute*. It has the force of a dependent clause, and thus may denote:

(*a*) *Time.*

ταῦτα ἔτυχεν ἄρχοντος τοῦ Κλέωνος, this happened when Cleon was archon.

(*β*) *Condition.*

Ἀθηναίων δὲ τοῦτο παθόντων νικηθησόμεθα, if the Athenians suffer this we shall be conquered.

(*γ*) A state of things in spite of which something happened.

καίπερ ὀλιγῶν ὄντων τῶν ἐν τῇ πόλει ἀπέβησαν οἱ Πέρσαι, although those in the city were few, the Persians went away.

(*δ*) *Cause.*

ὕοντος πολὺ οὐκ ἐβούλοντο περιμένειν, as it was raining heavily they did not wish to wait.

Note.—The genitive absolute, with a few exceptions, is used only when the subject of the participle is distinct from the subject of the sentence.

II. *Separation.*

1. After verbs meaning *to free from, keep off from, depart from*, &c., with or without prepositions.

οὐ μακρὸν ἀπέχει τῆς πόλεως, it is not far from the city.
ἐλευθέρου με τῶν φόβων, free me from my fears.

2. After adjectives compounded with α= without.

ἀτρύμων εἰμὶ τῶν ἐμῶν κακῶν, I am not worn out by my misfortunes.

3. After prepositions bearing a privative or separative meaning.

e.g. ἄνευ, ἀπό, ἐξ, &c.

4. After verbs indicating perception by the senses.

N.B.—In this case the genitive shows origin.

οὐκ ᾔσθετο τῶν νεφελῶν, he did not notice the clouds.

5. *Genitive of the Agent* with *ὑπό*.

ἐκολάσθη ὑπὸ τοῦ διδασκάλου, he was chastised by the teacher.

6. *Genitive of the Cause of Feeling.*

οἰκτείρω σε τῶν πάθων, I pity you for your misfortunes.

7. *Genitive of Origin.*

τοῦτο σοῦ ἔτυχον, I obtained this from you.

8. *Genitive of Comparison.*

τὸ ὅλον μεῖζόν ἐστι τοῦ ἡμίσεως, the whole is greater than the half.

N.B.—But note that when *ἤ* (="than") is used, the case of the thing with which comparison is made, as in English, is that required by ordinary rules of grammar.

e.g. φημὶ τὸν Κλέωνα σοφώτερον εἶναι ἢ ἐγώ, I say Cleon is wiser than I.

9. After words implying *fulness* or the reverse.

ὁ νέως πλήρης ἐστιν ἱερῶν, the shrine is full of priests.

ὀλίγου δέω, I want little.

Translate, giving every possible meaning of:

(1) *τὸ τῆς ἀρετῆς κάλλος*. (2) *ἀγαθῆς γυναῖκες πόθος*. (3) *ἡ εἰκὼν χρυσοῦ ἐστίν*. (4) *πίνετε μερός τι τοῦ οἴνου*. (5) *ἥδε ἡ κόρη θαυμασίου ἐστι κάλλους*. (6) *πολλῶν πόλεων ἡγεμονεύομεν*. (7) *ζῶντος τοῦ Λευκίππου οὐ δυνάμεθα νικᾶσθαι*. (8) *ἐδίωξε τὸν Σωκράτην ἀσεβείας*. (9) *ἅμα τελευτῶντος τοῦ θέρους ἔλαβον τὴν πόλιν*. (10) *τοῦ δ' αὐτοῦ χειμῶνος πρέσβεις ἔπεμψεν ἐς τὴν Σικελίαν*. (11) *οἱ δὲ Λακεδαιμόνιοι, γιγενημένου τοῦ ἐπὶ τῇ νήσῳ πάθους ἀνελπίστου, ἧττον ἐθάρσουν τῶν Ἀθηναίων*. (12) *ἡ νῆσος ἐτειχίσθη ὑπὸ τῶν ὁπλιτῶν*. (13) *φοβοῦμαι αὐτὸν πλέον σοῦ*. (14) *φοβοῦμαι αὐτὸν πλέον ἢ σύ*. (15) *φοβοῦμαι αὐτὸν πλέον ἢ ὑμᾶς*. (16) *χωρίζουσι τοὺς δούλους τῶν ἐλευθέρων*.

The Dative.—The dative case conveys three main meanings:

I. The person interested.
II. The instrument by means of which.
III. The place or time at or in which.

I. (1) *Indirect Object*—*i.e.* the person or thing to whom anything is told or given. This dative is used after many intransitive verbs signifying *pleasing, helping, sparing, giving, appearing, speaking*, &c.

ταῦτα μοι ἀρέσκει, this pleases me.
συγγιγνώσκω ὑμῖν, I agree with you.
λέγε μοι τοῦτο, tell me this.
νόμους ἔθετο ὁ Σόλων τοῖς Ἀθηναίοις, Solon gave laws to the Athenians.

Verbs of this class are used in the passive impersonally.

φαίνεταί μοι, it appears to me.

The use of the dative after words implying *likeness*, &c., is akin to the idea of the direct object.

αὕτη ἡ γυνὴ εἰκάζεται τῇ Ἀφροδίτῃ, this woman looks like Aphrodite.

(2) *Dative of Interest.*

πράττωμεν τοῦτο τῷ Σωκράτει, let us do this for Socrates.

Akin to this is the use familiarly known as the *Ethic Dative*, which is used in the case of personal pronouns to suggest *concern* or *interest* on the part of the person denoted.

τί μοι ποιήσεις; pray what will you do?

II. (1) *Dative of the Means, Cause, or Instrument.*

δεινῇ τινι νόσῳ διώλοντο, they perished from some dread disease.
τραυματισθεὶς τῷ τοῦ βαρβάρου ξίφει, wounded by the barbarian's sword.

(2) *Dative of Attendant Circumstances.*

σιγῇ ἀπέπλευσαν, they sailed away in silence.

(3) *Dative of the Agent* after the perfect passive and verbal adjectives.

οὐ καταφρονητέος ἐστιν ἡμῖν, we must not despise him.
φιλητέα ἐστί σοι ἡ μήτηρ, your mother should be loved by you.
οἱ Ἀθήναιοι νενίκηνται τῷ Γυλίππῳ, the Athenians have been defeated by Gylippus.

(4) *Dative of Accompaniment*, used in the following idiom:

ἔλαβον τὴν ναῦν αὐτοῖς ἀνδράσιν, they took the ship, crew and all.

III. (1) *Place at which.*

ἦν ποτ' ἀνὴρ Θήβαις, there was once a man at Thebes.

This use of the dative without a preposition is confined mainly to poetry.

The apparent datives in *-ι*, *e.g. Μαραθῶνι, οἴκοι, κ.τ.λ.*, are really survivals of the extinct locative.

(2) *Point of time.*

τῇ τρίτῃ ἡμέρᾳ ἐναυμάχησαν, on the third day they fought a naval battle.

Translate, giving every possible meaning of:

(1) ἔπειτα οἱ Πελοποννήσιοι ἐβούλοντο ἀμύνειν τοῖς Αἰγινήταις. (2) ἄμεινόν ἐστί σοι τοῦτο τειν. (3) τίς ἡμῖν ἐστιν οὗτος; (4) αὕτη ἡ ῥόδῳ ἐστὶν ὁμοία. (5) οἱ δ' Ἀθήναιοι τῷ ὕματι προσβάλοντες τοὺς ἐν τῇ πόλει ἠνάγκασαν ὁμολογίᾳ τὴν ἀκρόπολιν παραδοῦναι. (6) ἔδοξε τοῖς Λακεδαιμονίοις μείζονι στόλῳ τοῖς Δωριεῦσι τιμωρεῖν. (7) ποῦ κεῖνται οἱ Μαραθῶνι μεμαχημένοι; (8) τῇ αὐτῇ νυκτὶ ἀπέπλευσαν. (9) ἐν μέσῃ τῇ νυκτὶ ἀπέθανεν. (10) πλήθει βιαζόμενοι ἡσύχαζον. (11) οἱ γὰρ Ὀζόλαι ὅμοροί εἰσι τοῖς Ἀθηναίοις. (12) τῇ δ' ὑστεραίᾳ Τείχιον αἱρεῖ. (13) ὁ γὰρ ἡγεμὼν αὐτοῖς ἐτεθνήκη. (14) ηὗρε τὸν Ἀρχιμήδην ἐν τῷ οἴκῳ. (15) πεφοβημένοι τῇ μεγάλῃ τῶν πολεμίων ἰσχύι σιγῇ ἀνεχώρησαν. (16) δὸς δύο ὀβόλους τῷ Χάρωνι. (17) πειρατέον ἐστιν ἡμῖν παραπλεῖν τὴν Χάρυβδιν.

Syntax of the Verb. *Tenses: Present.*—The Present Tense in the *Indicative* represents three grades of meaning:

1. What happens at the present time (momentary action).

   ὁρῶ αὐτήν, I see her.

2. What is continuing to happen at the present time (continued action).

   εἰμὶ πόλλακις μετὰ τοῦ Σωκράτους, I am often with Socrates.

3. What is true at all times.

   οἱ θεοὶ φιλοῦσι τοὺς σοφούς, the gods love the wise.

In moods other than the indicative all idea of time disappears and the present simply indicates continued action.

Note.—An important exception to this is in the case of indirect speech.

The present has also a specialised use with adverbs or phrases indicating duration of time, by which it denotes something that began in the past and is still going on.

πέντε ἔτη πειρῶμαι πράττειν ταῦτα, for five years I have been (and still am) trying to do this.

The present tense is also used to indicate an attempted action.

πείθει με, he tries to persuade me.

Future Tense.—The future expresses:

1. What will take place (momentary).
2. What will be in the course of taking place (continued), at a time later than the present.

   πλανήσομαι, I shall wander, *or* I shall be wandering.

Note.—The subjunctive and imperative have no future. The future of the optative is only used in indirect speech to represent the future indicative of the direct.

The future infinitive (less often the present) is used after μέλλω to express either

1. Intention, or
2. Immediate futurity.

e.g. μέλλω ἀπίεναι, I am about to go away; I intend to go away.

Imperfect Tense.—The primary use of the imperfect is to denote what was happening at a moment in the past.

ἐνδιέτριβον αὐτόθι, they were wasting time there.

Akin to this sense is the meaning of doing a thing repeatedly in the past.

ἐγέλων τὸν Σωκράτην, they used to laugh at Socrates.

The imperfect is also used, like the present, with phrases denoting duration of time to indicate something that was happening at a given moment and had then been happening for some time.

πάλαι ταῦτα αὐτοῖς ἔλεγεν, he had been telling them this for a long time.

The imperfect tense is also used like the present to denote an attempt to do something.

ταῦτα πόλλακις ἐπράσσετο, this was attempted often.

Aorist Tense.—In the indicative the aorist expresses a momentary action in the past.

εἶδον τὴν βασίλισσαν, I saw the queen.

In the other moods, save in indirect speech, it denotes merely a single momentary act and carries no meaning of past time.

In the participle the aorist generally expresses time that is past in relation to the verb on which it depends.

e.g. ἰδών σε ἄπεισιν, having seen you, he will go.

ἰδὼν αὐτὸν ἄπιθι, when you see him, go.

The so-called *Gnomic* aorist (because used in γνῶμαι, proverbs) is used in the indicative to denote a statement of what generally happens.

πολλὰ παρὰ γνώμην ἔπεσεν, many things happen contrary to one's wishes.

The aorist (generally in the case of verbs which denote a condition) often expresses the beginning of the state of things of which the present denotes the continuance.

νοσῶ, I am ill; ἐνόσησα, I got ill.
γελῶ, I laugh; ἐγέλασα, I burst out laughing.

Perfect Tense.—The perfect represents an action as begun in the past and complete at the time of speaking.

Some perfect forms are by transference of ideas present in meaning. Among such are:

κέκτημαι, I possess (I have gained).
οἶδα, I know (I have seen).

Pluperfect.—This tense indicates that an act was, at a time in the past, completed.

ἤδη ἐλελύκεσαν τοὺς κύνας, already (at that time) they had loosed the dogs.

Future Perfect.—This tense denotes an act or state of things that will be complete at a future time.

e.g. ἤδη γεγράψεται ἡ τοῦ κρίτου γνώμη, the judge's decision will already have been written.

Translate, giving every possible meaning of :

(1) ὅταν ἄπηλθον ἀπεπεπόμφει τὸν ἄγγελον. (2) ἐπειδὴ ἐτελεύτησε ὁ Δαρεῖος, ὁ 'Αρταξέρξης κατέστη. (3) ὅταν εἶδον τὸν σὸν πατέρα, ἔμελλεν ἀπιέναι εἰς τὴν οἰκίαν. (4) ὥς γ' ἐμοὶ δοκεῖ, γίγνομαι θεός. (5) ἐν τῇ παιδίᾳ ἐφίλουν σφόδρα τὴν τίτθην. (6) δίδωμί σοι τοῦτον τὸν βίβλιον. (7) ἔδωκά σοι τοῦτο. (8) δέδωκά σοι τοῦτο. (8) πρίν σε προσελθεῖν, ἐπεφεύγεσαν. (9) ἔφυγον πρὶν ἡμᾶς ἀφικέσθαι. (10) ἥκω νέκρων κεύθμωνα λιπών.

The Use of the Moods in Simple Sentences :

Note.—In view of the interplay of the moods in the various types of simple sentence it has been thought better to deal with each type separately, showing how the different moods are used in each, it being felt that the use of the moods will thus more readily become a matter of instinct than if all the uses, say of the indicative, were exhausted before going on to deal with the subjunctive or optative.

Questions.—Questions that call for a direct answer are put in the *Indicative.* They are introduced by the following particles :

ἆρα when the answer is in doubt.
ἆρ' οὐ when the answer " Yes " is expected.
ἆρα μή / μῶν } when the answer " No " is expected.

N.B.—(1) μῶν is stronger than ἆρα μή. (2) ἆρα is often omitted.

e.g. ἆρα βέβληκα δὶς ἐφεξῆς ; have I thrown twice running ?

ὁ ναύτης ἆρα μὴ σωτηρίας ηὗρε μηχανήν ; did not the sailor find a means of safety ?

ἆρ' οὐκ ἄμεινον ἢ συ τὰν Θήβαις φρονῶ ; am I not wiser than thou in the affairs of Thebes ?

Double Questions—*e.g.* " Is he here or at Athens ? "—are expressed by πότερον or πότερα in the first part and ἤ in the second.

πότερον δέδρακεν ἢ οὔ, καὶ πότερον ἄκων ἢ ἑκών ; has he done it or not, and (if he has) was he unwilling or willing ?

Deliberative Questions—*i.e.* those which express doubt in the mind of the speaker as to what course to pursue—are put in the subjunctive. If negative, μή, not οὐ, is used.

τί φῶ ; what am I to say ?
τί μὴ λέγωμεν ; what are we not to say ?

Commands and Prohibitions.—Commands and prohibitions in the first person—*e.g.* " Let us do so-and-so "—are rendered by the subjunctive.

μὴ τοῦτο ποιῶμεν, let us not do this.
φέρε δὴ τὰς μαρτυρίας σοι ἀναγνῶ, come, let me read you the depositions.

Commands in the second and third persons are put in the imperative mood.

ἴθι δὴ κάλεσον τὸν προστάτην Κλέωνά μοι, quick, run and call my patron Cleon here.
παρίστασθον παρὰ τὼ πλάστιγγε, each of you stand beside his scale.
αὐτὸς ὁράτω, let him see for himself.

Second and third person prohibitions that are *general* are expressed by the imperative.

ἡ κλέπτε, do not steal.

Those that are *special*—*i.e.* that refer to a particular act that is forbidden—are expressed by the aorist subjunctive.

μὴ κλέψῃς τοῦτον τὸν ἵππον, do not steal this horse.

Wishes.—Wishes are of two sorts :

1. Those that are capable of fulfilment.
2. Those that are not.

1. *Wishes capable of Fulfilment.*—Obviously, the only kind of wish that can be fulfilled is one that refers to the future. In Greek a future wish can be expressed as follows :

i. By εἴθε or εἰ with the optative.
ii. By the optative alone.

εἴ μοι γένοιτο φθόγγος, may I find speech.
ὦ παῖ, γένοιο πατρὸς εὐτυχέστερος, my lad, mayst thou be more happy than thy father.
εἰ γὰρ 'Αθήνη κάρτος ἐμοὶ δοίη, would that Athene would give me strength.

2. *Wishes that cannot be Fulfilled.*—The only wishes that from their nature are incapable of fulfilment are those that relate to the past or to the present, which nothing can alter. Such wishes are expressed in Greek :

i. By εἴθε or εἰ with the indicative.
εἴθε μὴ ἐγένετο, would that it had not happened.
εἰ γὰρ ἦν ἐν ταῖς 'Αθήναις, would I were in Athens.

ii. By ὤφελον = I ought (aorist of ὀφείλω = to owe) with the infinitive.

ὤφελον εἶναι ἀμείνονος ἀνδρὸς ἄκοιτις, would I were (*lit.* I ought to be) the wife of a better man.

μηδ' ὤφελεν ὁ ξένος ἀπολέσθαι, and would that the stranger had not perished.

Note.—In all wishes the negative is μή, not οὐ.

The Infinitive.—The infinitive is generally called a verbal noun because it has some of the properties both of a verb and of a noun.

In the following respects it is a noun:

1. It can govern or be governed by a verb.
2. By means of the article it can be put into any case.

In the following respects it is a verb:

1. It can govern or be governed by a noun as object or subject.
2. It can be modified by adverbs.
3. It can be put into any voice or tense.

φιλῶ τὸ πίνειν, I love drinking.

ἡ τοῦ πίνειν ἡδόνη, the pleasure of drinking.

τὸ βελτίων γενέσθαι ἄριστον ἐστίν, to improve is best.

τὸ τὴν ἀρετὴν διώκειν ἄγει εἰς τὸ εὖ ζῆν, to pursue virtue leads to living well.

Note.—(1) Note that all words which depend on or qualify the infinitive go between it and the article. (2) The infinitive with the article is abstract in its meaning.

βούλομαι ἀπελθεῖν, I wish to depart.

οὐ θανεῖν θέλω, I do not desire to die.

Some verbs of *saying*, &c., take as their object an infinitive governed by a noun or pronoun. The noun or pronoun is in the accusative case, except when it refers to the subject of the main verb, in which case it is attracted to the nominative, or omitted, as in the second and third of the following examples:

φησὶν αὐτὴν καλλίστην εἶναι, he says she is very lovely.

οὐκ ἔφη ἥδεσθαι, he said he was not glad.

ἔφη αὐτὸς μέλλειν ἀποπλεύσειν, he said he himself intended to sail away.

Note.—The subject of the infinitive may be attracted to any case in which is put the noun to which it refers.

ἔδοξέ μοι γενέσθαι πένητι, I decided (it seemed good to me) to be poor.

The infinitive is used without the article after some verbs as a kind of object—that is to say, as expressing the end to which the action of the verb is directed. The *present* or *aorist* tense is generally used.

e.g. βούλομαι ὡς τάχιστα ἀποθανεῖν, I wish to die as quickly as possible.

κινδυνεύει δουλεύεσθαι, he runs the risk of being made a slave.

ἀξιωθήσεται θανεῖν, he will be judged worthy to die.

Note that after verbs implying *to promise, intend,* or *hope,* or similar meanings, when a future object is referred to, the *future* infinitive is used.

ἤλπιζον μάχην ἔσεσθαι, they expected there would be a battle.

ἠγγυᾶτο μηδὲν αὐτοὺς κακὸν πείσεσθαι, he promised that they should suffer no harm.

μέλλει τὸ Ῥήγιον χειρώσεσθαι, he intends to subdue Rhegium.

Explanatory Infinitive.—The infinitive is used without the article to modify the meaning of many adjectives and nouns.

ὥρα ἀπιέναι, it is time to depart.

δεινός ἐστι λέγειν, he is skilled in speaking.

οὐκ ἄξιός ἐστιν ἀποθνήσκειν, he does not deserve to be killed.

The infinitive is also used with adjectives and verbs to restrict their application to a certain specific action.

e.g. οἰκία ἡδεῖα ἐνδιαιτᾶσθαι, a house pleasant to live in.

λόγος ῥᾴδιος κατανοῆσαι, a speech easy to understand.

θαῦμα ἰδέσθαι, a wondrous thing to see.

θείειν ἀνέμοισιν ὁμοῖος, like the winds in speed (*lit.* in running).

Infinitive expressing Purpose.—The infinitive alone is used, *always in the active voice,* to express purpose.

e.g. παρέδωκαν τὴν πόλιν αὐτοῖς φυλάττειν, they gave up the city to them to guard.

οὐκ εἶχον ἀργύριον ἐπισιτίζεσθαι, they had no money to buy food.

It is also used with similar force after verbs implying *to hinder*, and the like.

εἴργει με τὰ ἄριστα διώκειν, he prevents me from pursuing what is best.

Occasionally the infinitive is used to express purpose after ἐφ' ᾧ or ἐφ' ᾧτε, which then mean "for the purpose of."

e.g. ᾑρέθησαν ἐφ' ᾧτε βοηθεῖν ὑμῖν, they were chosen for the purpose of helping you.

But the more common use of ἐφ' ᾧ and ἐφ' ᾧτε is in the meaning "on condition of."

e.g. ἄφεισαν τὸν Σωκράτην ἐφ' ᾧ μηκέτι φιλοσοφεῖν, they let Socrates go on condition of his no longer being a philosopher.

Infinitive expressing a Result.—The infinitive is used after ὥστε and sometimes after ὡς to express the natural result of an action.

e.g. οὐχ οὕτως ἀγαθός ἐστιν ὥστε μηδέποτε ἁμαρτάνειν, he is not so good as never to err.

This use is specially idiomatic after comparatives with ἤ = than.

e.g. σοφώτερός ἐστιν ἢ ὥστε τοῦτο ποιεῖν, he is too wise to do this.
Less often ὥστε is omitted.
κακὸν μεῖζον ἢ φέρειν, an evil too great to bear.

Parenthetical Infinitive.—The infinitive is used, generally with ὡς or ὅσον, as a parenthesis, qualifying the whole sentence.

e.g. οἱ ἄνθρωποι, ὡς ἔπος εἰπεῖν, δουλεύουσι τῇ τυχῇ, mankind, so to speak, are slaves of chance.
τοῦτο, ἐμοί γε δοκεῖν, οὐ δύναται ἀληθὲς εἶναι, this cannot be true, as it seems to me.

Infinitive after πρίν.—πρίν, meaning *before*, and referring purely to time, takes the infinitive in Attic Greek *when it depends on an affirmative clause.*

ἀποπέμπωμεν αὐτὸν πρὶν ἀκοῦσαι, let us send him away before we have heard him.
πρὶν ἔκπυστος γενέσθαι, προσῆλθεν, he came up before he was discovered.

Note.—In constructions with the infinitive *the negative is always μή.*

The infinitive is regularly used after the 3rd person singular of some verbs used impersonally. The commonest such verbs are:

πρέπει, προσήκει = it is fitting.
δοκεῖ = it seems good.
δεῖ, χρή = it is required.
συμβαίνει = it happens.
ἔνεστι = it is possible.
ἔξεστι = it is allowed.

e.g. δεῖ ἡμᾶς ἐλθεῖν, we ought to go.
δοκεῖ αὐτοῖς ἐλθεῖν, it seems good to them to go.
ἔξεστιν ἡμῖν ἐλθεῖν, we are allowed to go.
πρέπει σε λέγειν, it is fitting that you should speak.

Translate: (1) ἆρ' εὐτυχεῖς ἢ δυστυχεῖς; (2) ἆρ' οὐ χρὴ τοιοῖσδε χρησμοῖς πεποιθέναι; (3) ἆρα μὴ ἀπόντος αὐτοῦ κατηγόρησας; (4) πότερον ὑπισχνεῖ μοι νῦν βοηθήσειν ἢ οὔ; (5) πότερον μένωμεν ἢ φεύγωμεν, οὐδεμίας ἔτι ἐλπίδος οὔσης; (6) ἐπιχειρείτω τὸ ἔργον. (7) μαχώμεθα τῆς πόλεως ἕνεκα τῆς νῦν κινδυνευούσης ἀπολέσθαι. (8) μὴ κατηγόρει τοῦ Σωκράτους. (9) μήποτε ἀναιτίου κατηγορήσῃς. (9) ἐμοῦ γε ζῶντος ταῦτα μηδέποτε τύγχανοι. (10) πῶς ἂν γενοίμην ἀνὴρ ἀγαθός. (11) εἴθε μὴ οἱ Συρακόσιοι νικῷεν ἐν τῇ ναυμαχίᾳ. (12) εἴθ' ὤφελ' Ἀργοῦς μὴ διαπτάσθαι σκάφος. (13) ὤφελες ἀξίως πρᾶξαι. (14) εἰ τὸ φιλοσοφεῖν ἐφίλεις. (15) πολλοὶ γὰρ ἐνόμιζον αὐτὸν ἀσκεῖν τὴν ἀρετήν. (16) τί γὰρ τιμῶσιν οἱ ἄνθρωποι πλέον ἢ τὸ τῶν ἐχθρῶν φείδεσθαι; (17) ῥᾳδίως κατεγνώσθη διὰ τὸ μὴ δύνασθαι ψευδῆ λέγειν. (18) δεῖ αὐτοὺς ἀποθανεῖν. (19) ἐδέοντο αὐτῆς ἀγγέλλειν ταῦτα τῷ βασιλεῖ. (20) ἔφη Ὀλυμπίοις ἀποπλεύσεσθαι. (21) πᾶσι τοῖς βροτοῖς ἔξεστιν εὐδαίμοσιν εἶναι. (22) οὐκ ἔφη τὸν Κῦρον μέλλειν πολεμήσεσθαι. (23) βούλομαι αἱρεῖν τὰς ναῦς αὐτοῖς ἀνδράσιν. (24) πάρειχον ἐμαυτὸν τοῖς πολεμίοις ἀποκτεῖναι. (25) ὁ Ἀλκιβιάδης ἠγγέλθη νικῆσαι. (26) δεινὸς ἦ ὁ Ἀλκιβιάδης ἐξαπατᾶν τοὺς Ἀθηναίους.

Participles.—Besides its use as a simple adjective, the participle is used in the following ways:

1. With the article very frequently where in English we should use a relative clause.

ὁ στρατηγὸς ὁ τὴν Ἑλλάδα σεσωκώς, the general who has saved Greece.
οἱ τὴν ἀρετὴν ἀσκοῦντες εὐδαίμονές εἰσιν, those who practise virtue are happy.

N.B.—In negative clauses of this type οὐ is used if the clause is definite, μή if it is indefinite.

e.g. οἱ οὐ φιλοῦντες τὴν εἰρήνην, those (particular individuals) who do not love peace.

οἱ μὴ φιλοῦντες τὴν εἰρήνην, those (whoever they are) who do not, &c.

2. After the following classes of verbs:

(*a*) Verbs of perceiving, mentally and by means of the senses, and verbs which express emotion.
αἰσθάνομαι γελοῖος ὤν, I perceive that I am ridiculous.
αἰσχύνομαι τοῦτο ποιῶν, I am ashamed at doing this.
ἤκουσεν αὐτὴν ἐν πόλει ὄντα, he heard that she was in the city.

(*b*) Verbs implying *showing, declaring*, &c.
φανερός εἰμι ἀδικήσας, I clearly did wrong.
ἐδήλωσεν αὐτοὺς σοφίστας ὄντας, he showed that they were sophists.

(c) Verbs implying *beginning, continuing*, or *ending*.
δεῖ παύειν αὐτὸν γελῶντα, we must stop his laughing.
ἄρχεται διδάσκων τὸ φιλοσοφεῖν, he is beginning to teach philosophy.
διετέλουν καθεύδοντες, they continued to sleep.

(*d*) In a special idiom after *λανθάνω* = I escape notice; *τυγχάνω* = I chance; *φθάνω* = I come first.

e.g. *ἔφθασαν ἀφικόμενοι*, they arrived first.

φθάνω εὐεργετῶν, I am the first to do a kindness.

αἱ ναῦς λανθάνουσι τοὺς πολεμίους ἀφορμηθεῖσαι, the ships put to sea unobserved by the enemy.

ἔτυχον πότε εὐδαίμων ὤν, I happened then to be prosperous.

Note.—Note that in the case of *λανθάνω*, occasionally the idiom is reversed, the verb of action being finite and *λανθάνω* going into the participle. Thus, "He went away secretly" can be *ἔλαθεν ἀποβάς* or *ἀπέβη λαθών*.

3. The most regular use of the participle, however, is adverbial—that is to say, it qualifies the meaning of a verb. When thus used the participle agrees with a noun or pronoun expressed or understood, but stands without the article. Used in this way it can express:

i. *Time*—

ἀπήντησα Φιλίππῳ ἀπιόντι, I met Philip as he was leaving.

δειπνήσαντες ἀπελαύνετε, when you have had supper, ride off.

ii. *Means* by which a thing is done—

λῃζόμενοι ζῶσιν, they live by plunder.

iii. *Attendant circumstances*—

ναῦς δώδεκα λαβόντες ἀπέπλεον, they took twelve ships and sailed away.

ἔρχεται τὸν υἱὸν ἔχουσα, she comes with her son.

iv. *Purpose* (generally expressed by the future participle).

παρελήλυθα συμβουλεύσων, I have risen to give my advice.

ἦλθε τὴν εἰρήνην ἀγγελῶν, he came to announce the peace.

v. *The Cause* of an action.

ἀπείχετο τοῦ πίνειν, αἰσχρὸν νομίζων εἶναι, he avoided drinking because he believed it to be base.

τί παθὼν τοῦτο ποιεῖ; what has happened to him that he does this?

vi. *A Condition.*

ποίησας ταῦτα κατακριθήσει ἀποθνήσκειν, if you do this you will be condemned to death.

vii. *Concession*—*i.e.* to express the idea of "although."

ὀλίγα ἔχων πολλὰ ἀπεδιδου, though possessed of little he used to give away much.

This idiom is especially frequent with *καίπερ* = although, or *καί*.

πείθου γυναιξί, καίπερ οὐ στέργων, give way to women though you love them not.

The use of the participle in the *Genitive Absolute* construction and of the neuter of the participle of impersonal verbs in the *Accusative Absolute* construction has already been dealt with under the heads of Accusative and Genitive respectively.

Verbals in -τέος.—The verbal adjective in *-τέος* implies *necessity*. It is used in two ways:

1. Adjectivally.
2. Impersonally.

1. *Adjectival.*—In this construction the verbal is merely an adjective agreeing with a noun and is used only with transitive verbs. It takes the dative of the agent.

οὗτος ὁ ἀνὴρ τιμητέος ἐστιν ἡμῖν, this man must be honoured by us.

2. *Impersonal.*—In this construction the verbal is in the nominative neuter (generally singular), and is followed by the verb "to be" either expressed or understood. In sense it is equivalent to *δεῖ* with the infinitive. It takes the dative or accusative (the latter not frequently) of the agent.

e.g. *πειστέον σοι τάδε*, you must obey in this.

τί ἂν αὐτῷ ποιητέον εἴη; what would he be obliged to do?

ἐψηφίσαντο πολεμητέα εἶναι, they voted that they must go to war.

Translate: (1) *βουλόμενος τὰ δίκαια πράττειν ἤχθη ὑπὸ τῶν ἑταίρων εἰς τὸν ὄλεθρον.* (2) *οἱ τοιαῦτα λέγοντες ἐπιλανθάνονται τῶν ὄντων.* (3) *οὐκ ἀεὶ οἰκτείρονται οἱ δυστυχοῦντες.* (4) *ὁ τοῦ Περίκλους ἀσεβείας κατηγορήσας πάρηλθεν ἀγγελῶν τὸν ἄρχοντα καίπερ ἀχθόμενον μέλλειν τὸ δέον ποιήσειν.* (5) *μετεμέλοντο οὐ βοηθήσαντές σοι κινδυνεύοντι.* (6) *διατελεῖ τοὺς ἄρχοντας μάτην προσερχόμενος.* (7) *ἐλάνθανε δεινότατα νοσῶν.* (8) *ἔτυχεν ὁ Ἀλκιβιάδης τότε φεύγων.* (9) *ἑλὼν τὴν Ὄλυνθον παρέδωκεν.* (10) *εὖ γ' ἐποίησας ἀναμνήσας με.* (11) *δὸς τῷ ξένῳ ταῦτα φέρων.* (12) *ἦλθε τὴν θυγατέρα λυσόμενος.* (13) *τί γὰρ δεδιότες σφόδρα οὕτως ἐπείγεσθε;* (14) *προείλετο μᾶλλον τοῖς νόμοις ἐμμένων ἀποθανεῖν ἢ παρανομῶν ζῆν.* (15) *τοὺς Ἕλληνας ἐδίδαξεν ὃν τρόπον διοικοῦντες τὰς αὐτῶν πατρίδας μεγάλην ἂν τὴν Ἑλλάδα ποιήσειαν.* (16) *τυραννεύσας δ' ἔτη τρία ἐχώρει ἐς Σίγειον.* (17) *φημὶ δὴ διχῇ βοηθητέον εἶναι τοῖς πράγμασιν ὑμῖν.* (18) *φράζουσιν ὡς οὐ σφι στεριοπτέη ἐστὶν ἡ Ἑλλὰς ἀπολλυμένη.* (19) *οὐ παραδοτέα ἐστι τοὺς συμμάχους.*

Compound Sentences.—So far only simple sentences have been dealt with—that is to say, sentences in which each verb stands independent of the others and expresses a separate thought. The stage has now come at which compound sentences must be considered. A compound sentence consists of a simple sentence with one or several clauses

depending on it—that is to say, they represent a thought that exists only in some relation to the main sentence.

The commonest forms of compound sentence are treated below, grouped according to general type.

Result.—There are several ways in Greek of expressing the result of an action. Of these the most general is by means of the conjunction *ὥστε*=so that. *ὥστε* is used in two constructions:

(i.) With the *infinitive*, the negative used being *μή*.

e.g. *ἐκάετο ἡ νόσος ὥστε μὴ ἀλλό τι ἢ γύμνοι ἀνέχεσθαι*, the disease burned so that they could not endure aught but to be naked.

οὐ τηλίκος ἐστιν ὥστε δεσπότῃ πάντα πιθέσθαι, he is not of such age as to obey his master in all things.

(ii.) With the *indicative*, the negative being *οὐ*.

βέβηκεν, ὥστε πᾶν ἐν ἡσύχῳ ἔξεστι φωνεῖν, he has gone, so that thou mayst say all undisturbed.

οὕτω φρενοβλαβεῖς ἦσαν ὥστ' οὐκ ἐβούλοντο σωθῆναι, they were so crazy that they did not wish to be saved.

The precise shade of difference between the two constructions is that the infinitive emphasizes the fact of the result, while the indicative emphasizes the result as a fact.

Thus in the second example under (ii.), had the sentence read *ὥστε μὴ βούλεσθαι*, the translation would have been, "They were so crazy as not to wish," &c.

Result can also be expressed by the relative pronoun with the indicative.

e.g. *τίς οὕτως ἀγνώμων ἐστιν ὅστις ἐλπίζει ἀθάνατος γενήσεσθαι;* who is so senseless as to hope to become immortal?

Cause.—Dependent sentences expressing the cause of the principal clause are introduced by one of the following conjunctions:

ὅτι, ὡς=because.
ἐπεί, ἐπειδή, ὅτε, ὁπότε=since.

The mood used is the indicative, and the negative is expressed by *οὐ*.

e.g. *γλαυκὴ δέ σ' ἔτικτε θάλαττα ὅτι σοι νοῦς ἐστιν*, the grey sea bare thee, since thou art so hard of heart.

λέγε μοι ταῦτα ἐπεί συ μόνος οἶσθα, tell me this, since you alone know it.

ἄπειμι ὅτε δὴ τοῦτο οὐκ ἔχω ποιεῖν, I will go away since I cannot do this.

The optative is sometimes used *when the main verb is in a past tense* to indicate that the cause is not so much one believed in by the speaker as one suggested to him by someone else.

e.g. *ἐχθρὸς ἐγένετο τῷ Περικλεῖ ὅτι οὐ σέβοι τοὺς θέους*, he became an enemy of Pericles because (as he said) he did not reverence the gods.

This shows the feeling of the person spoken of and not the speaker's own opinion.

The relative pronoun is also sometimes used to introduce a causal sentence.

e.g. *οὐκ ἄξιον ποιεῖς ὅς οὐδὲν δίδως τοῖς πένησιν*, you act unworthily in that you give nothing to the poor.

Purpose.—The largest class of clauses expressing purpose is introduced by one of the following conjunctions:

ἵνα=in order that.
ὡς, ὅπως=so that.
μή=lest, in order that . . . not.

As regards mood, the dependent clause follows what is known as the sequence of moods, that is to say:

1. When the main verb is in a *Primary* tense, the dependent verb goes in the *Subjunctive*.
2. When the main verb is in a *Historic* tense, the dependent verb goes in the *Optative*.

Note.—When it is desired to indicate more vividly the actual thought that was in the mind of the subject of the main verb and prompted his action, the subjunctive can be used even after a historic tense.

The negative particle is *μή*.

ἄπιθι μὴ ἀποθάνῃς, depart lest thou die.
παρῆλθεν ἵνα μάθοι τι καινόν, he came in order to learn something fresh.
λίσσεται τὸν θέον ὅπως νημερτὲς εἴπῃ, he begs the god to speak sure truth.
διανοεῖται τὴν γέφυραν λῦσαι ὡς μὴ διαβῆτε, he proposes to break up the bridge so that you may not cross.

Occasionally, when it is desired to denote that the object sought was not achieved, a past tense of the indicative is used where the optative would be expected.

τί οὐκ ἔκτεινας αὐτὸν ἵνα μὴ προὐδώκε τὴν πατρίδα; why did you not kill him so that he might not have betrayed his country?

Purpose can also be expressed by the use of the future participle:

ἀγγέλους ἔπεμψεν εἰρήνην αἰτήσοντας, he sent envoys to ask for peace.

The use of the relative pronoun with the future indicative after a primary main verb is also equivalent to a purpose clause.

δοῦλον ὠνήσομαι ὅστις τοῦτο ποιήσει, I will buy a slave to do this.

Under the head of purpose clauses comes the use of *ὅπως* and the *Future Indicative* after verbs implying an *attempt* or *precaution*, or the like.

δεῖ ἡμᾶς σκοπεῖν ὅπως ταῦτα μὴ γενήσεται, we must see to it that this does not come about.

μηχανώμεθα ὅπως σώσομεν αὐτόν, let us plan to save him.

In phrases implying a caution the verb enjoining caution is generally omitted.

e.g. ὅπως δὲ τοῦτο μὴ διδάξεις αὐτήν, take care not to teach her this.

Here also is to be noted the idiom by which *μή* in affirmative statements and *μή οὐ* in negative statements are used after verbs expressing fear.

e.g. φοβοῦμαι μὴ ταῦτα μάθῃ, I fear he will learn this.

φοβοῦμαι μὴ ταῦτα οὐ μάθῃ, I fear he will not learn this.

ἐδείμαινε μὴ ταῦτα γένοιτο, he feared this would happen.

Note that the sequence of moods is normally regular. But when it is desired to intimate fear that something is in fact happening or has actually happened, the indicative may be used in the dependent clause.

e.g. δέδοικα μὴ νοσεῖ, I fear he is ill.

φοβοῦμαι μὴ ἡμαρτήκαμεν τῆς ὁδοῦ, I fear we have lost our way.

Translate: (1) *εἴκοσι ἔταξαν ναῦς ἐπὶ τῷ δεξιῷ κέρᾳ, ὅπως μὴ διαφύγοιεν οἱ Ἀθήναιοι.* (2) *οὐ γὰρ ἦν προσδοκία μὴ ἄν ποτε οἱ πολέμιοι ἐπιπλεύσειαν.* (3) *κρύσταλλος γὰρ ἐπεπήγει οὐ βέβαιος ἐν τῇ τάφρῳ ὥστ' ἐπελθεῖν.* (4) *ἡ νὺξ πολὺ τὸ ὕδωρ ἐπεποιήκει, ὃ μόλις ἐπεραιώθησαν.* (5) *ἔδεισαν μὴ ὅπερ ἐν Ναυπάκτῳ γένοιτο.* (6) *πολλοὶ τῶν πολιτῶν διεφθείροντο, ὅτι οὐ συνηγωνίζοντο.* (7) *δεδοίκασι μὴ λόγοις ἥττους ὦσι.* (8) *τοῦτο δὴ ἐγένετο ὥστε ἀποπλῆσαι τὸν χρησμόν.* (9) *ψυχρότερόν ἐστι τὸ ὕδωρ ἢ ὥστε λούσασθαι.* (10) *ταῦτα τὰ ἀγαθὰ δοκεῖ ἡμῖν παντὸς ἄξια εἶναι, ὥστε πάντες τὸ καταλιπεῖν αὐτὰ φεύγομεν.* (11) *ὅπλα κτῶνται οἷς ἀμύνονται τοὺς ἀδικοῦντας.* (12) *δεῖ ἡμᾶς τιμᾶν τὸν Ἀπόλλωνα ὅποτε θέος ἐστιν.* (13) *πρῶτον μὲν τὰ πλοῖα ἐμπρησαν, ὅπως ἀπόγνοια ᾖ τοῦ κρατεῖν τῆς γῆς.* (14) *ὁ δὲ Δημοσθένης δείσας μὴ κυκλωθῇ, λοχίζει ὁπλίτας ἐς τετρακοσίους ἐς ὁδόν τινα κοίλην.* (15) *πέμπει εὐθὺς τοῦ στρατοῦ μέρος τι τὰς ὁδοὺς προλοχιοῦντας καὶ τὰ κάρτερα προκαταληψομένους.* (16) *οὐ δεῖ σε, φοβούμενον μὴ οὐ γνῷς τὴν τῆς γῆς φύσιν, ἀπέχεσθαι γεωργίας.* (17) *οὐχ οὕτως ἀσθενής εἰμι ὥστε μὴ δύνασθαι πέντε σταδίους ἐν μιᾷ ἡμέρᾳ χωρεῖν.* (18) *δέδοικα μὴ νημερτῆ εἶπεν.*

Conditions.—A conditional sentence consists of two clauses, one containing the condition, and the other stating what follows as a result of the condition. The former is called the *Protasis;* the latter, which is the principal clause, is called the *Apodosis.* For example, in the sentence, "If you are well, I am happy," "If you are well" is the protasis, laying down the condition, while "I am happy" is the apodosis, which states as the principal fact what follows as a result of the condition being fulfilled.

There are four sorts of conditions:

1. *Particular Vivid,* where the protasis states a particular condition, and the apodosis follows naturally if the condition is fulfilled, without anything being said as to whether it is in fact fulfilled or not.

Type: "If so-and-so is the fact, then . . ."

A condition of this type may be past, present, or future in time.

(*a*) *Past* and *Present.*—In past or present vivid conditions the protasis is introduced by *εἰ* and the mood used in both protasis and apodosis is the indicative.

εἰ ὑγιαίνεις, ἐγὼ εὐδαιμονῶ, if you are well, I am happy.

εἰ μὴ ὑγιαίνεις, ἐγὼ οὐκ εὐδαιμονῶ, if you are not well, I am not happy.

εἰ τοῦτο ἐποίησας, καλῶς ἔπραξας, if you did this, you acted nobly.

εἰ ἡμῶν ἐπιλέλησται, νικήσομεν, if he has forgotten us we shall conquer.

(*b*) *Future.*—In future conditions of this type the protasis is introduced by *ἐάν* (*εἰ ἄν*) with the subjunctive, while the verb of the apodosis is in the future indicative.

φεύξεται, ἐὰν μὴ πείθηται τοῖς νόμοις, he will be prosecuted if he does not (in the future) obey the law.

ἐὰν ὁ Κῦρος ταῦτα πύθηται, χολώσεται, if Cyrus learns this, he will be angry.

2. *General Conditions.*—(*a*) *Present.*

Type: "If ever so-and-so happens, then . . ."

The protasis has *ἐάν* with the subjunctive, and the apodosis has the present indicative.

ἐὰν μὴ οἱ ἄνθρωποι εὐπράττωσι, κατηγοροῦσι τοὺς θέους, if men do not prosper, they accuse the gods.

ἐάν τις ἀσκῇ τὴν ἀρετήν, οὐ δύναται μῶρος καλεῖσθαι, if a man practises virtue, he cannot be called a fool.

(*b*) *Past.*

Type: "If ever so-and-so happened, then . . ."

The protasis has εἰ with the optative, and the apodosis has the imperfect indicative.

εἴ τις παραβαίη, ζημίαν αὐτῷ ἐπετίθεσαν, if anyone transgressed, they used to penalise him.

εἴ τι μὴ φέροιμεν, ὤτρυνεν φέρειν, if we did not bring him something, he used to urge us to do so.

3. *Vague Future Conditions.*

Type: "If so-and-so were to happen, then . . . would," &c.

The protasis has *εἰ* with the optative, and the apodosis has the optative with the particle *ἄν*.

εἰ ἔλθοι εἰς τὰς Ἀθήνας, τάχεως ἂν πείθοι τοὺς κριτάς, if he were to go to Athens he would soon persuade the judges.

εἰ δ' Ἀγησίλαος μὴ νικῴη ἐν τῇ μάχῃ, οἱ Λακεδαιμόνιοι οὐδὲν ἂν πειρῷντο πλὴν ἀναχωρεῖν, if Agesilaus were not to win the battle, the Lacedaemonians would attempt only to retreat.

4. *Unfulfilled Conditions.*—In conditions of this class the apodosis states what would happen if the condition of the protasis were fulfilled, though in fact it is not fulfilled.

Type: "If so-and-so were true (but it is not), then," &c.

The historic tenses of the *indicative* are used in both protasis and apodosis, and the particle *ἄν* is also used in the apodosis.

The tenses are used as follows:

The *Imperfect* can denote an action as
(*a*) going on now, or
(*b*) going on in the past.

The *Aorist* denotes an action as occurring in the past.

The *Pluperfect* denotes an action as being completed in the present or the past.

ταῦτα οὐκ ἂν ἐδύναντο ποιεῖν εἰ μὴ ἐμαίνοντο, they could not do this if they were not crazed.

εἰ ἦσαν ἄνδρες ἀγαθοὶ οὐκ ἄν ποτε ταῦτα ἔπασχον, if they had been good men, they would never have suffered these things.

εἰ παρήλθετε ἐδιώκομεν ἂν τοὺς Πέρσας, if you had come, we should now be pursuing the Persians.

Time.—In clauses expressing temporal relations no difficulty is presented if it be borne in mind that in essence many of them are of the nature of conditions and are constructed accordingly.

The rules for dependent time clauses can be epitomised as follows:

1. If a definite time is denoted, the indicative is used, the negative particle being *οὐ*.

ἐπεί, ὡς = "when," *ἐπειδή* = "after that," and *ἕως* = "while," "until," are most generally used to introduce definite temporal clauses.

e.g. ἕως ἐστὶ καιρός, ἀντιλάβεσθε τῶν πραγμάτων, while there is an opportunity, take the matter in hand.

ἐπεὶ ὑπηντίαζεν ἡ φάλαγξ καὶ ὁ σάλπιγξ ἐφθέγξατο, after the column began to advance and the bugle had sounded.

N.B.—Note the effect of the imperfect *ὑπηντίαζεν*.

2. When the time is indefinite it is expressed (*μή* being the negative particle):

(*a*) When it refers to the present or future, by adding *ἄν* to the conjunction and putting the verb in the subjunctive.

Note.—Note that *ὅτε, ὁπότε, ἐπειδή* coalesce with *ἄν* to form *ὅταν, ὁπόταν, ἐπειδάν*.

e.g. ταῦτα, ἐπειδὰν περὶ τοῦ γένους εἴπω, τότε ἐρῶ, I will speak of this when I (shall) have spoken of my birth.

ἐπειδὰν δὲ ἡ ἐκφορὰ ᾖ, λάρνακας φέρουσιν, when there is a funeral procession they carry coffins.

τίνα οἴεσθε αὐτὴν ψυχὴν ἕξειν, ὅταν ἐμὲ ἴδῃ; what do you think her feelings will be when she sees me?

(*b*) When it refers to the past, or when the main clause is apodosis of a vague condition in the optative, by the conjunction without *ἄν* with the optative.

ἤσθιεν ὁπότε πεινῴη, he used to eat whenever he was hungry.

εἰ νοσοίη, πάντες σιωπῷεν ἂν ἕως κάθευδοι, if he were to be ill, all would keep silent while he slept.

Note that: (1) After *ἐν ᾧ* or *ἕως* = "while," past or present time is treated as definite, future time as indefinite.

(2) After *ἕως* = "until" the same rule applies.

N.B.—*ἕως* = "until" is never used after a negative main clause.

(3) *πρίν* = "until" or "before," when it follows a negative main clause, is subject to the same rule.

(4) *πρίν* = "before," after an affirmative clause, is constructed with the infinitive, as illustrated above under the head of "Infinitive."

Relative Clauses.—Clauses introduced by a relative pronoun are for all practical purposes

conditional, and are constructed accordingly. The kinship between

ἃ μὴ ἐβούλετο δοῦναι, οὐκ ἂν ἔδωκεν, he would not have given what he had not wished to give,

and

εἴ τινα μὴ ἐβούλετο δοῦναι, οὐκ ἂν ἔδωκεν, if he had not wished to give anything he would not have given it,

is obvious at once; and similar relationship between relative and conditional clauses can be recognised in all cases with more or less ease. The following examples should be translated back into conditional form in order to attain familiarity with the conditional idiom:

οὓς δὲ μὴ εὕρισκον, κενοτάφιον αὐτοῖς ἐποίησαν, for those of them whom they did not find they raised a cenotaph.

νικῴη δ' ὅ τι πᾶσι μέλλει συνοίσειν, may anything prevail which will benefit all.

οὐκ ἂν οὕτως ἐπεχειροῦμεν πράττειν ἃ μὴ ἠπιστάμεθα, we should not thus be undertaking (as in fact we are) to do things that we did not understand.

δεῖ σε πάντα λέγειν, ἵνα ἃ ἂν ἐκείνῳ δοκῇ ταῦτα πράττηται, you must say all, so that whatever shall seem good to him may be done.

πῶς ἂν εἰδείης περὶ πράγματος οὗ ἄπειρος εἴης; how could you know about a thing of which you had no experience?

οὓς δ' ἴδοι σιωπῇ ἰόντας ἐπῄνει, all those whom he saw going in silence he used to praise.

Translate: (1) *εἰ ταῦτα οὕτως ἔχει, ἥδομαι.* (2) *εἰ ὁ παῖς ἀπόθανοι, ἄχθοιτο ἂν ἡ μήτηρ.* (3) *εἰ ἀπέκτειναν αὐτὸν πόνηροι εἰσίν.* (4) *ἐὰν ὁ σοῦ ἀδελφὸς ἀναγκάζῃ σε τοῦτο πράττειν, θαρσάλεως σοί πρακτέον ἔσται.* (5) *ἐπειδὰν τελέσῃς εἰπών, πάντες πρὸ σοῦ ἀναβοησόμεθα.* (6) *ὁπότε, ἀπαντήσειαν ἀλλήλοις, παίζονεν περὶ τούτων.* (7) *ὁπόταν ἴδῃς τὸν Περίκλεα ἀνάμνησον αὐτὸν τῶν πρὶν ὑποσχέσεων.* (8) *ἐπεὶ ἀπῆλθον οἱ Πέρσαι, ἠρξάμεθα ἐργαζόμενοι τοὺς ἀγρούς.* (9) *εἰ τοῦτο εἶπας, ἥμαρτες ἄν.* (10) *τάχεως ἂν σοὶ ἐδίδουν ὅ τι εἶχον.* (11) *οἱ γὰρ πολέμιοι ἀποκτενοῦσι πάντας οὓς ἂν ἕλωσιν.* (12) *εἰ δὲ σὺ τὰ τῆς πόλεως πράττοις, πάντες ἂν οἱ καλοὶ κἀγαθοὶ εὐτυχοῖεν.* (13) *ἐὰν ταῦτα εἴπῃς, ἁμαρτήσει.* (14) *ἕως ἂν μὴ στρατεύηται, τὰς σπονδὰς οὐ λύσει.* (15) *ἀληθές ἐστιν ὅ τι ἂν λέγῃ.* (16) *εἰ μὴ τὴν πόλιν ἔσωσεν, οὐκ ἂν νῦν ἐτίματο.* (17) *πρὶν μὲν γὰρ κριθῆναι οὐ ῥᾴδιόν ἐστιν εἰδέναι τὰς αἰτίας.* (18) *οὐ πρότερον ἐπανέστη Μαρδόνιος πρὶν ἢ σφᾶς ὑποχειρίους ἐποιήσατο.* (19) *οὐκ ἄπειμι πρὸς δόμους πάλιν, πρὶν ἂν σε ἔξω βάλω.*

"*Though*" *Clauses*.—The idea contained in the English word "although" can be expressed in Greek in the following ways:

(*a*) By using *εἰ καί, ἐὰν καί, καὶ εἰ,* or *κἂν* (*καὶ ἐάν*) in one of the various forms of condition, as though the English were "even if," &c.

e.g. καὶ εἰ μὴ δυνάμεθα δῶρα δοῦναι, οὐδέποτε νικώμεθα, although we cannot give bribes we are never defeated.

ἐὰν καὶ δυστυχῶμεν, οὐκ ἀδικήσομεν, although we suffer misfortune, we will not do wrong.

(*b*) By using *καί* or *καίπερ* with the participle, very often with *ὅμως* = "nevertheless" in the main clause.

e.g. πείθου γυναιξὶ καίπερ οὐ στέργων, obey the women, though you love them not.

ἐποικτείρω αὐτὸν καίπερ μοι ὄντα δυσμενῆ, I pity him though he is my enemy.

ἅλις ἤδη εἴρημαι καὶ πολλὰ παραλιπών, I have already said enough, though I have passed over much.

Indirect Speech.—Indirect speech is the narration of what someone thought or said: the thought or words narrated depend on a verb implying *saying, thinking,* &c. Thus "I am going" is what someone actually said—*i.e.* direct speech. If I am reporting his words to another person, I can do so either by using inverted commas, "He said, 'I am going,'" or by using indirect speech, "He said that he was going."

In English indirect speech is expressed by the use of the conjunction "that," together with a change in the time of the narrated verb so that it adopts the time of the verb on which it depends, as in the example above.

In Greek there are three means by which indirect speech may be expressed:

(*a*) When the verb that introduces the speech narrated takes the infinitive or a participle, the *principal verb* of the speech narrated is put into the infinitive or participle in the same tense as that of the direct speech. If *ἄν* was used in the direct speech, it is preserved in the indirect.

e.g. ὁ δὲ Κλέων οὐκ ἔφη αὐτὸς ἀλλὰ τὸν Νικίαν στρατηγεῖν, Cleon said that not he, but Nicias, was general.

ὁ Κῦρος λέγεται γενέσθαι Καμβύσεω, Cyrus is said to have been the son of Cambyses.

ἤλπιζον τοὺς 'Αθηναίους ἴσως ἂν ἐπεξελθεῖν, they hoped the Athenians would perhaps march out. (Direct speech would be *ἴσως ἂν ἐπεξέλθοιεν*.)

ἔφη ἐντὸς ἡμερῶν εἴκοσιν ἄξειν αὐτούς, he said he would bring them within twenty days. (Direct speech would be *ἄξω αὐτούς*.)

Κῦρον ἐπιστρατεύοντα αὐτῷ ἐγὼ πρῶτος ἤγγειλα, I first announced that Cyrus was on his march against him. (Direct speech would be *Κῦρος ἐπιστρατεύει σοί*.)

οὐκ ᾔδεσαν αὐτὸν τεθνηκότα, they did not know he had died (*i.e.* τέθνηκε in direct speech).

ηὗρον οὐδαμῶς ἂν ἄλλως τοῦτο διαπραξάμενος, I found I could accomplish this in no other way (*i.e.* οὐδαμῶς ἄλλως διαπραξαίμην ἄν).

(β) In cases other than those dealt with above, indirect quotations are introduced by ὅτι or ὡς = "that," and are subject to the following rules as to sequence:

i. When the tense of the introducing verb is primary, the verb of the narrated speech remains in the same mood and tense as in direct speech.

e.g. μάρτυρας παρέξομαι ὡς ταῦτ' ἀληθῆ λέγω, I shall bring witnesses to prove that I speak the truth (*i.e.* they will say "ταῦτ' ἀληθῆ λέγει").

ii. When the tense of the introducing verb is historic:

(*a*) The indicative or subjunctive of direct speech either changes to the same tense of the optative or keeps its original mood and tense.

e.g. ἐπειρᾶτο δεικνύναι ὅτι οἱ 'Αθήναιοι φαίνοιντο μὲν εἶναι ἄνδρειοι, εἶεν δ' οὔ, he tried to show that the Athenians appeared to be brave, but were not so (*i.e.* φαίνονται μὲν εἰσὶ δ' οὔ).

εἶπεν ὅτι ὁ τύραννος τέθνηκεν, he said that the tyrant was dead (*i.e.* ὁ τύραννος τέθνηκεν).

(*b*) A historic tense of the indicative that denotes an unfulfilled condition, and all optative tenses are kept without change.

εἶπεν ὅτι ταῦτα οὐκ ἂν ἐδύναντο ποιεῖν εἰ μὴ ἐμαίνοντο, he said that they could not do this if they were not mad (*i.e.* οὐκ ἂν ἐδύναντο, εἰ μὴ ἐμαίνοντο).

N.B.—By the rule stated immediately above this could never be οὐκ ἂν δύναιντο, &c.

εἶπεν ὅτι εἰ ἔλθοι εἰς τὰς 'Αθήνας τάχεως ἂν πείθοι τοὺς κριτάς, he said that if he were to go to Athens he would soon persuade the judges (*i.e.* εἰ ἔλθοι, τάχεως ἂν πείθοι).

(γ) *Dependent Verbs in Indirect Discourse.*—While the principal verbs of compound sentences follow the above rules in indirect speech, dependent verbs obey the following rules:

i. When the introducing verb is in a primary tense, dependent verbs do not change either mood or tense.

ii. When the introducing verb is historic, dependent primary tenses of the indicative and dependent subjunctives may either change to corresponding tenses of the optative or remain as they are. Dependent historic tenses of the indicative are not, however, changed.

e.g. ἀποκρινεῖται ὅτι δοῦλον ὠνήσεται ὅστις τοῦτο ποιήσει, he replies that he will buy a slave to do this (*i.e.* δοῦλον ὠνήσομαι ὅστις τοῦτο ποιήσει).

λέγει ὅτι ἐπειδὰν ἐκφορὰ ᾖ, λάρνακας φέρουσιν, he says that when there is a funeral procession they carry coffins (*i.e.* ἐπειδὰν ἐκφορὰ ᾖ, λάρνακας φέρουσιν).

ἔφη αὐτοὺς ὅτι ἐκφορὰ ᾖ (or εἴη), λάρνακας φέρειν, he said that when there was a funeral procession they carried coffins. (*i.e.* ἐπειδὰν ἐκφορὰ ἐστί).

ἔφη οὐκ ἂν δοῦναι ἃ μὴ ἐβούλετο δοῦναι, he said he would not have given what he had not wished to give (*i.e.* οὐκ ἂν ἔδωκεν ἃ μὴ ἐβούλετο).

ἠρώτησαν πῶς ἂν εἰδείη περὶ πράγματος οὗ ἄπειρος εἴη, they asked how he could know about a thing of which he had no experience (*i.e.* πῶς ἂν εἰδείης περὶ . . . οὗ . . . εἴης).

οὐ and μή.—A summary of the uses of the two different negatives may at this stage be useful.

The regular negative is οὐ. μή, however, is used in its stead in the following cases:

(*a*) With the subjunctive.
(*b*) With the imperative.
(*c*) In dependent purpose clauses. (But note that after μή = "lest," οὐ is used.)
(*d*) In all conditions.
(*e*) In relative clauses where the antecedent is indefinite, *i.e.* where the relative clause is equivalent to a condition.
(*f*) In time clauses under similar circumstances.
(*g*) In wishes.
(*h*) With the infinitive. (*N.B.*—But not in indirect speech.)
(*i*) With participles and adjectives that are equivalent to relative clauses with an indefinite antecedent.

e.g. οἱ οὐ φιλοῦντες τὴν εἰρήνην = those (particular individuals) who do not love peace.

But οἱ μὴ φιλοῦντες τὴν εἰρήνην = those (whoever they are) who do not love peace.

Thus οἱ μὴ ἀγαθοί = all those who are not good; οἱ οὐκ ἀγαθοί = those individuals who are not good.

(*k*) After verbs signifying *fearing, hindering,* &c.

The following instances of double negatives should be noted:

(*a*) Where μή is used to negative an infinitive,

if the verb on which the infinitive depends is itself negatived, the infinitive takes the double negative μή οὐ.

e.g. ἄξιός ἐστι μὴ ἀποθανεῖν, "he deserves not to die," becomes, when negatived, οὐκ ἄξιός ἐστι μὴ οὐκ ἀποθανεῖν, "he does not deserve not to die."

The same rule applies when the main verb is in the form of a question, but a negative is implied:

διὰ τί ἄξιός ἐστι μὴ οὐκ ἀποθανεῖν; "why does he deserve not to die?"—implying that he does not so deserve.

(b) οὐ μή is used as follows:

i. With the aorist subjunctive and future indicative as a stronger form of the negative.
   οὐ μὴ τοῦτο ποιήσῃ, he will never do this.
   οὐ μή σε πέμψω, I certainly will not send you.

ii. With the second person of the future indicative with the force of an emphasized prohibition.
   e.g. οὐ μὴ λαλήσεις, leave off chattering.

GREEK LITERATURE

The history of Greek literature may be divided into three epochs:

1. Early Literature, down to the first quarter of the fifth century B.C.
2. Attic Literature, from about 470 B.C. to the close of the fourth century.
3. The Literature of the Decline, which again falls into two periods:
   (a) The Alexandrian, from 300 B.C. to the middle of the second century.
   (b) The Graeco-Roman, from about 150 B.C. to about A.D. 500.

1. **Early Literature.**—It has been frequently pointed out that Greek literature, in contrast with the literatures of more modern times, is distinguished and its development is explained by the fact that it was essentially oral. The form which prevailed—epic, lyric, rhetoric, dialogue, or drama—each in turn was addressed to an audience rather than to a reading public. Such being the case, it is easily understood how the form adopted varied according to the variation in social conditions. The laurels awarded to merit were distributed not, as at Rome, by the decision of a few cultured experts, but according to the favour of the public at large, who heard the work of an author in the theatre, at feasts, in the courts, or in the assembly. So long as a great public was at liberty to express its opinions freely, literature flourished; when public liberty was lost, literature declined and became pedantic and academic.

The earliest extant works are the **Homeric poems.** Tradition tells us of songs earlier than Homer, which, from the vague details available, appear to have been of a ritualistic nature. In the history of Greek literature they play no other part than to form a beginning from which it may be traced.

The *Iliad* and the *Odyssey*, the two great Homeric poems, are now agreed to be composite works and not the creation of one author, the legendary Homer. Inconsistent details of style and matter, and the linking together of a series of seemingly irrelevant main episodes, lead to the belief, now general, that the poems represent accretions of legends, similar in character and nearly contemporaneous, into a more or less coherent whole. The probability is that in the first place different tales of well-known heroes of legend or memory were recited by professional story-tellers at feasts or similar gatherings, and that gradually the details became traditional and uniform, until the different tales were united, first perhaps as a series, and finally to make a single connected story.

Both the poems are divided into twenty-four books. The *Iliad* tells the story of the wrath of Achilles against the Greeks besieging Troy, the consequent Trojan successes, and the final return of Achilles to the field to avenge his slaughtered friend, resulting in the beginning of the Trojan downfall by the death of their champion Hector.

The *Odyssey* is the account of the wanderings of Odysseus after the fall of Troy, until he arrives once more at his home on Ithaca and triumphs over the suitors of his wife who have been trying to usurp his place.

Apart from the value of Homer as illustrating a civilisation which is only now beginning to be known, the *Iliad* and *Odyssey* rank as treasures of poetry. The sonorous rhythm of the hexameter verses in which they are composed has a beauty of its own; born of the recitative with which the ancient story-teller aided his memory, it possesses a flexibility and a majesty that later epic poets could only attain by conscious effort.

Beyond this, Homer possesses to the highest degree that simplicity of language and directness of expression, that human feeling and instinctive sense of the dramatic, that mark the great poet.

As regards date, the first recorded collection of the works of Homer is placed towards the end of the sixth century B.C.: from internal evidence the two poems seem to have originated in Ionia approximately 1000 B.C.

Numerous minor epics and hymns have been assigned to Homer, particularly the beautiful hymn to Demeter. No other reason for crediting

him with their authorship seems to exist than that their origin is very ancient and their authors unknown.

The next name in historical order is that of **Hesiod.** There is little doubt that, just as all the romantic epics were fathered on a mythical Homer, so the didactic epics were the putative offspring of Hesiod. Later in date than the *Iliad* and *Odyssey*, three of the Hesiodic poems survive.

Of these, the most interesting is the *Works and Days*, a treatise, or rather a series of hints, on agriculture, which form the backbone of the poem and are treated with an air of truth and considerable poetic feeling. To eke them out are interspersed a number of moral sayings, and a digression into the subject of the lucky and unlucky days of the month. The poem as a whole is more pedestrian than Homer; it is essentially peasant literature, and was the beginning of the characteristic poetry of Boeotia, Hesiod's home, which was always a land of husbandry.

The *Theogony*, next in importance, is a family history of the Gods. Its most interesting feature is the glimpses it gives of primitive myths too crude and prehistoric to be found elsewhere in Greek literature, which take us back to extreme antiquity.

The *Shield of Herakles* relates one of the legends about the hero and is mainly taken up with a description of his shield, in imitation of a similar description in the *Iliad*. It is inferior to its original, being full of dull particularity and lacking in imagination.

Many poems of the same school at one time existed, but survive now only in their titles. Their general character was the same; they dealt either with arts and crafts or with the commonplaces of morality.

As time went on and political consciousness developed, men no longer were content to assign their own compositions to a legendary Homer or Hesiod. The same circumstances tend to induce the poet (for in the early stages poetry is the only form of literature) more and more to express his own personality and to write what he thinks himself. This feeling of the need for self-expression gave birth to another metre than that of the epic; the heroic hexameter was too restricted as to the themes to which it lent itself. As a result there came into being the elegiac and the iambic metres.

The elegiac metre, originally associated with songs of mourning, as well as the iambic, came to be used to express the personal interests of the author; no theme came amiss to it, and it dealt now with war, now with love, now with politics or philosophy, always in a more or less conversational manner. At one thing it stopped short; the fervour of true lyric poetry was a height to which it could not attain.

The earliest elegiac poets were **Callinus** and **Tyrtaeus**, both belonging to the first quarter of the seventh century B.C. They sung of wars and noble deeds, but the wars were the wars of their fellow-men and not of legendary heroes. **Mimnermus of Colophon**, who has been given a later date, sang also of wars; but his principal theme was love and the personal longing of a luxurious nature for the delights of peace.

With **Solon** at the end of the seventh century we come nearer to an historical personality. Up till then there is always the feeling that the poet is merely a personification; that Tyrtaeus is held responsible for all elegy of a certain kind, just as all heroic epic has been laid to the account of Homer. Solon's elegiac poetry strikes out a new line, abandoning the heroic note and dealing with politics and ethics. From what survives we can see that no high level of poetry was attained.

Theognis of Megara, some eighty years later in date, is a truer poet than Solon; capable of expressing deep feeling, he strings together a number of maxims that show great strength of personality together with extreme narrowness of outlook.

The iambic metre (from ἰάπτω, to dart) was at first that used for the scurrilous jests bandied about at the feasts of Demeter. Its use by **Archilochus** for satire (680 B.C.) can be understood—not satire in the modern sense, however, aimed at individuals, but satire directed against the classes to which he was politically opposed. A freebooter and a poet, Archilochus has some affinity with the French Villon.

Hipponax (*c.* 540 B.C.) also wrote personal epigrams, but on a less exalted scale.

As the epic declined there grew up two other forms of poetry, lyric and choric. The Greeks were a song-loving race, and songs became part of their literature at an early date. The song pure and simple first took the form of traditional folk-songs, of which a survival is extant in the delightful Swallow-song which was sung in Rhodes at the spring festival. Tradition could not always, however, suffice for the artistic needs of the public; songs were required for public ceremonies and for private merrymakings, and poets arose to supply the deficiency. The first lyric poet known to us is **Alcaeus**, who flourished in the first half of the sixth century B.C. Alcaeus provided a new metre, distinctive and effective, which marked a departure from the heavier metres of epic and elegiac poetry. A fighter and a roisterer, he sang of war, wine, women, and party. His verses were full of fire and gained in force from the simplicity of their expression.

Alcaeus' younger contemporary, **Sappho**, the famous poetess of Lesbos, carried on his

tradition. Her verses show more variety of metre and, as might be expected, deal chiefly with themes of love and personal feeling. For beauty of expression she stands unsurpassed among the women-writers of the world.

At a later date (his traditional *floruit* is placed at 545 B.C.) arose **Anacreon**, also a singer of wine and love. But to these themes he added, for the first time, epigrams of a personal nature which served as a model for centuries after.

The needs of the community, as distinct from those of individuals, gave rise to choric poetry. The ceremonials of public gatherings, which were generally religious, required some medium for the expression of communal feeling, and this was provided by the choric song. At first composed for the community, as communal feeling waned the choric song came to be composed at the order and for the pleasure of private patrons.

A particular form of the choric song was the Dithyramb (*Δι*=god, *θρίαμβος*=rejoicing), a kind of mystery-play, in which a chorus, disguised as satyrs or centaurs, sang in praise of a god or enacted some episode to his glory. This was the real *τραγ-ῳδία* or Goat-song, which contained the germ that was to develop into Attic tragedy.

Alcman, the first of the choric poets, who flourished about 650 B.C., has only come down to us in fragments. His themes were mainly those of love, but he also wrote a sort of dramatic part-song in which several divisions of the chorus sang in turn.

Some fifty years after Alcman a new element was introduced into the choric poem, which was to have a far-reaching effect. **Stesichorus of Himera** in Sicily was the first to leaven the lyrical element with the epic, and to make the poem tell a story. Besides dealing with the great legends of gods and heroes, he made a further innovation by singing of legends of humble life which depended for their effect on the innate beauty of their sentiment rather than on a lofty theme. The fragments of his poems are remarkable for their strong dramatic power and their beautiful expression, and mark the beginning of the great period of choric poetry.

Simonides, the next great lyrist, flourished between 530 and 470 B.C. Renowned as a wit and a man of culture, he obtained a great reputation all over the Greek-speaking world. He wrote poems for occasional purposes—to celebrate a victory, to hallow a festival, or to congratulate on some private occurrence. The first to write definitely on private commission, he introduced the *ἐπινίκιον*, the ode celebrating victory at the games, wherein mention of the winning athlete or chariot and their patron or master is made an incident in a poem of larger interest. Nothing florid mars his poetry; in such lines as the epitaph on the heroes of Thermopylae—

> "Stranger, bear word to the Spartans that we
> lie here obedient to their charge."
> (Murray's translation.)

—he illustrates the Greek ideal of simple beauty and severe self-restraint.

Bacchylides, nephew of Simonides, followed along the lines pointed out by the latter as far as simplicity of style is concerned. He is notable for introducing the epic style into his poems to a greater extent than the other choric poets; his similes are rather quietly decorative than brilliant, and he adopts the epic manner of giving to nouns of importance each its own conventional epithet.

The *ἐπινίκια* of Bacchylides differ from others in that he makes more play with the details of the particular victory that he is celebrating, and is not content with a mere mention of it in the course of the poem.

The Dithyrambs, which constitute the other half of Bacchylides' works, are epic episodes in choric form.

Last of the choric poets comes **Pindar**, belonging in point of date (522–442 B.C.) to the Attic period, but ranking in point of style with the writers of the early period. With him the particular form of literature that he adopted reached both its height and its decline.

In spirit Pindar was behind his times; the champion of racial prejudice and religion as understood by the temple priests, he was more in harmony with the age when local gentry were proud to trace their descent back to the semi-divine heroes of saga than with the political freedom and communal consciousness that were stamped on the Greek cities that repulsed Darius and Xerxes.

Unfortunately, Pindar's only surviving works are the series of odes which celebrate victories at the Pythian, Nemean, Isthmian, and Olympic games, though we know that his poems included dithyrambs, hymns, and other choric forms. The outstanding characteristics of his poetry are his obscure style, which makes him perhaps the most difficult of Greek writers to read and to appreciate, and the quality that is a worthy set-off to that disadvantage, the true poet's inspiration, which depicts a scene, describes an emotion, or epitomizes a moral sentiment, in a few sparkling words. The difficulty of Pindar and the archaic nature of his thoughts cannot mar that quality of the true poet which makes the reader feel that in no other way could his thought have been so beautifully or so adequately expressed.

So far all the writers considered have been poets. Verse is naturally the earliest form in which man records his thoughts, principally owing to the aid which it affords the memory in an age when writing, if known, is a matter

of great tediousness and expense. Towards the latter end, however, of the early period, prose writing began to be practised, taking its rise in the Greek cities of Asia Minor. It assumed one of two forms, either chronicles or speculation, which were to develop later into the histories of Herodotus and Thucydides in the one direction, and the writings of the philosophers, culminating in the dialogues of Plato and the treatises of Aristotle, in the other. **Hecataeus of Miletus** (520 B.C.) and **Herodotus of Heraclea** (500 B.C.) stand out from the list of mere names as actual writers whose works, speculative and historical, are known to us vividly by reputation, though they have not survived.

2. **The Attic Period.** *Tragedy*.—The outstanding feature of the first part and middle of this period is the rise of tragedy to its zenith. To repeat what has been said of its origin, the germ of tragedy is found in the more or less primitive festival to a god, at which the band of worshippers sing a hymn describing the legend of the god or some incident therefrom. The divinity most generally thus celebrated was Dionysus, with whom the performances in the theatre came to be associated, so that his priest was always the central figure in the audience.

The simple chorus gradually develops a leader, who assumes the part of the god or his emissary and narrates the story with intervals of praise by the chorus.

The next step, and the first hint of dramatization, is when the leader does not sing to the chorus, but carries on a dialogue with the coryphaeus, the chief of the chorus. According to tradition, this was an innovation of **Thespis**, an Athenian poet of about 530 B.C., who may thus be said to have originated the tragic drama.

Of all the tragic poets who won popular favour, **Aeschylus** is the earliest who has survived. In technique he is said to have been the first to make the innovation of introducing a second actor besides the coryphaeus. The dialogue now carries the main burden of the play and stands independent of the chorus, which becomes of secondary importance.

The result of the Persian wars and the repulse of the power of the East were bound to affect the imagination of a poet who was himself an actor in some of the most stirring scenes of the war. Consequently Aeschylus is inspired by a Panhellenic patriotism such as no other Greek poet knew, while the awful lesson of the ruin of the great Persian expedition is reflected in the doctrine preached by him throughout, that self-restraint, the ideal Greek virtue, must never be relaxed, and that one momentary lapse into ὕβρις, "overweeningness," is sufficient to call down Nemesis from heaven and to start a whole train of evils.

The seven plays of Aeschylus that are extant show unsurpassed grandeur of language and of conception. The thought is speculative but not unorthodox; its main trend is to reconcile the seeming divergence between the will of the gods in heaven and the powers below, the solution to the problem being that all that happens is constrained by necessity in order to work out in full the law of righteousness.

After Aeschylus comes his younger contemporary, **Sophocles** (496–406 B.C.), whose tragedies mark a further advance in dramatic technique by the introduction of a third actor and painted scenery specially adapted to the particular play. He also survives in seven tragedies only, though he was a voluminous producer. Less grand in style than Aeschylus, he was a more conscious artist. His language is polished in the extreme, and the tragedies come nearer than those of Aeschylus or Euripides to modern ideas of well-constructed drama. He is remarkable for his skill of plot and his mastery of character delineation. Speculation as to the meaning of the legends that form his themes is no concern of his; he seeks only to show how men and women would speak or feel or act if all the circumstances of the traditional tale were true, and by his command of language and poetical feeling to raise the tale to the level of great poetry.

With **Euripides** (480–406 B.C.), the last of the great triad in development, we come to a different mental atmosphere. Saturated with the scepticism of late fifth-century Athens, he is yet not in sympathy with the sceptics around him. Unlike Sophocles he is not content to use the legends as he finds them merely as material for a play; he draws a lesson from each—not the lesson of inscrutable wisdom and order that inspired Aeschylus, but the lesson that picturesque glamour is a snare, that men are carried away by conventional appearances and do not understand the real meaning of what they see. When he thinks of war, he visualises not the triumph of the victors and the noble glory that they win, but the agony of the vanquished and the ignominy and suffering that follow on defeat. To him a victory means not a triumphant return of happy warriors, but the cries of widowed women, orphaned children, and ravished maidens. Especially did he attack the position of all good conservatives that the interest of the state must be served at the expense of individuals, whatever cruelty or wickedness it may involve. His wonderful power of pathos strengthens the effect of his teaching, and it is small wonder that the Athenian public, when the tide of war turned against them and they were seeking strength in a frenzied patriotism, came to hate and to fear him.

If one is asked to place Euripides in the development of Greek tragedy, it can be said

that, while he shows a decline from the restrained and formal beauty in which the Greek was always best expressed, he marks an approach to the humanity of interest that men value to-day.

Comedy.—Little is known of the early history of comedy save that, like tragedy, it took its rise in a religious celebration, that of Dionysus, and owed its inception to the coarse jesting and horseplay that mark the lighter side of a feast of the common people.

Before the Attic period the comic drama is in darkness: it is known merely that a poet of Megara, one **Susarion**, about 580 B.C. produced some sort of farce. This was probably of the type in which a chorus, itself or through a leader, bandied rude jests with one another or even with the audience. It was in Attica and in the fifth century that comedy took artistic shape. The names survive of **Cratinus and Eupolis**, who produced comedies between 480 and 420 B.C. Their works have not survived, but it is known that Cratinus altered the form of comedy considerably, modifying the number of actors and introducing for the first time that element of personal attack which characterized the old Attic comedy. That comic dramatists were abundant from about 470 B.C. onwards is certain, but the earliest comedies that have come down to us are those of **Aristophanes**, whose activity ranged from 427 B.C. over a period of about forty years.

The eleven plays of Aristophanes that we possess fall roughly into three classes, reflecting the differing political conditions of the times at which they were produced. Those dated between 425 and 421 B.C.—the *Acharnians*, *Knights*, *Wasps*, *Clouds*, and *Peace*—are unrestrained in their abuse of those to whom or to whose policy the poet objects. Later, when amid the public misfortunes popular taste was more subdued, the *Birds*, *Lysistrata*, *Thesmophoriazusae*, and *Frogs* depart more into the realms of fancy; while in the *Ecclesiazusae* and *Plutus*, written after the final disaster had overtaken Athens, the satire is directed against general tendencies, and party politics are not touched.

Aristophanes' place in literature is unique. Master of rhythm and metre, possessed of a poet's rich fancy which he lavished on his choruses, and with a sense of comedy unequalled in any age, he is the sole representative of a wonderful phase of a wonderful time.

After Aristophanes, the "Middle" comedy down to about 320 B.C. continued to develop towards the romantic plays of the "New" comedy. The lashing political satire of the *Knights* and the *Wasps* becomes softened into satire on literature and social tendencies, as foreshadowed in Aristophanes' latest plays, until at last the satire almost disappears and gives place to characterisation and romance.

Prose.—The epoch which witnessed the zenith and decline of tragedy, and in which comedy came into being, also saw the beginning of prose composition and its more gradual development to its best. So late a development may be explained by the influence of the epic, which in one form or another furnished a medium for moralising, declamation, instruction, and inventiveness. There were, of course, records of various kinds that were in prose, for the most part inscriptions on bronze or stone. Each city had its chronicles, which were kept up to date and expanded as needs required, but these were a mere collection of statements; anything approaching to literary style was unknown to them. The first definitely prose-writers were the Ionians, **Hecataeus** and **Herodotus**, at the end of the sixth century.

From Ionia prose-writing shifted its centre to Athens, where the rapid growth in the political importance of the city and the rise of the democracy brought to the front those who could speak or write, to take part in the increasing activity in the assembly and the courts. Attic Greek became the recognised literary medium, and Athens herself became the centre whither flocked the ablest men in Greece.

The earliest extant prose work is the essay on the Athenian constitution, so long attributed to Xenophon, but now recognised to be the writing of an unknown author, called for convenience the **Old Oligarch**. In date it belongs to the period of the first Athenian Empire. It is an attack on the democracy, written in familiar and vivid language. Of style there is little; the sentences are disconnected and the grammar is colloquial.

Some years later in date is the historical work of Herodotus. Though he writes in the Ionian dialect, **Herodotus** is kin to the spirit of Attic literature. His history is a series of accounts of different countries, made up of legends, actual records, and the result of personal observation, the whole being strung together to make a history of the war with Persia. In effect the work is a drama, the theme being the tragedy which inspired Aeschylus in the *Persae*, the punishment meted out to the overweening self-confidence of the great king.

As a historian Herodotus deals too much in the legendary and relies too much on hearsay to be of great value. As an artist, however, who can invest mere stories with the truth of a knowledge of human nature and can make phantom characters seem alive, he is hard to surpass. He stands half-way between the mythographers and geographers of Ionia and

the purely historical writings of Thucydides and Xenophon.

While Herodotus was writing his history in the Ionic dialect of the old writers of λόγοι, the dialect of Attica was being worked up and moulded into a literary vehicle of the utmost power. The Sophists, **Protagoras** and **Gorgias**, by their writings and disputations, and **Prodicus** by his speeches and lectures, exercised a great formative influence on the artistic development of prose style. At the same time public oratory, especially at the hands of **Pericles** and **Antiphon**, in turning to practical use the newly-awakened medium of expression, helped to give to prose its life, power, and polish.

Under these influences there leaped up suddenly the history of **Thucydides**. Historically the successor of Herodotus, Thucydides is as precise and scientific as the former is diffuse and romantic. For some reason his language is a conventional Ionic-Attic. He says ξύν for σύν, πράσσω for πράττω, &c., but in spirit and style he is an Attic writer. In eight books he gives an account of the Peloponnesian war, with the object, as he tells us, of giving to the world a thing of value for all time. He achieves this by carefully investigating facts, making clear the connection between events and their cause, and displaying throughout a truthfulness, impartiality, and consistent relevancy which make his history rank, as it does, among the masterpieces of its kind. Thucydides' literary power is evidenced particularly in the speeches which are here and there inserted in accordance with ancient practice; he does not pretend that they are authentic, and he does not use them merely to display his rhetorical skill, but makes them disclose the motives and sentiments of the speakers.

In style Thucydides is terse, vivid, and restrained. His choice of language is occasionally almost poetic, and he makes great play with the use of antithesis. The congestion of ideas that makes him so difficult for the student to read is due to the rapidity with which his mind works; before an idea is well expressed he is already mentally engaged with its logical sequence. Historically Thucydides is priceless: he gives the impression, so seldom obtained from ancient writers, that what he says is true and may be depended on as an authority.

The mantle of Thucydides was carried by **Xenophon**: he never succeeded in wearing it. The seven books of his *Hellenica* form a continuation of Thucydides, going down to 362 B.C. Partiality for Sparta, and want of a central idea or any scientific plan, mar the value of the work and discount the effect of clear and lively writing. Others of Xenophon's works are of great interest, notably those reminiscent of Socrates, which give us the actual man as compared with the idealisation of Plato. The most famous and, as a narrative, the best of Xenophon's works is the *Anabasis*, the account of how ten thousand Greeks, stranded in Asia Minor, made their way under his leadership through a difficult and hostile country to the sea. In minor works on hunting and other subjects Xenophon appears as the earliest essayist, while the *Education of Cyrus* is a political and philosophical romance.

Oratory.—In a state where the popular assembly and the law-courts played so large a part in every man's life as at Athens, the art of rhetoric was bound to be of importance and to affect the general progress of literature. The feeling for effective oratory was fostered by the Sophists of the second half of the fifth century, who dwelt on the importance of grammar and logic, of whom **Gorgias** obtained a high reputation as a rhetorician.

The earliest of the Attic orators is **Antiphon** (480–411 B.C.), who wrote speeches for litigants. His style is simple and dignified, relying on pathos rather than on subtlety.

Andocides (467–390 B.C.) is one of those speakers whose graphic diction sounds better than it reads: he is not so much an orator as a ready speaker. His language is plain, and he makes little use of the rhetorical figures of speech.

Lysias (458–378 B.C.) marks the successful marriage of perfect literary finish and everyday Attic idiom. While polished and effective, he steers clear of all rhetorical figures save the antithesis so dear to the Greek heart.

Isocrates (436–338 B.C.) was never a forensic orator; he wrote for a reading public, and so came to establish a standard for rhetorical prose. A political essayist and educationalist, he was widely read and his influence was widespread, even Cicero confessing to being his debtor. His language is pure and not too florid, but his composition is distinguished by ample periods, by conscious avoidance of all harshness, and by a tendency to use with discrimination the recognised rhetorical figures. Isocrates shows the transition from the purest prose endowed with spirituality to an artificial prose richer in technique but less sincere and less precise.

Isaeus (420–348 B.C.) has some of the conciseness, simplicity, and vividness of Lysias, but his style differs from that of the earlier writer in the consciousness of artistry that pervades it. In arrangement of subject, elaboration of proof, and in dealing point by point with an adversary's speech, he gave a new trend to Attic oratory and set a model which was to be followed by the most brilliant of all Greek orators.

With **Aeschines** and **Demosthenes** comes the end. Demosthenes fittingly closes the list of

great speakers, himself the greatest of all. Aeschines, his contemporary and adversary, was theatrical and brilliant, but not convincing; Demosthenes, a natural orator, was in command of every resource of language and of argument, uniting in himself all the best elements in those who had preceded him. We know him best of all the Greek orators, for we possess sixty of his speeches, of which the most important, both from the fierceness of their technique and the magnitude of their themes, are the speeches against Philip of Macedon (*Philippics*), the *Olynthiacs*, and the speeches on the Peace, the Crown, and the Embassy.

After Demosthenes some fame was won by **Lycurgus** and **Hyperides**, but oratory, in common with political freedom, gradually declined.

Philosophy.—The earlier philosophers—**Heraclitus**, **Anaxagoras**, and **Democritus**—wrote in the Ionic dialect. Heraclitus (died 475 B.C.) of Ephesus survives only in fragments of his work on Nature. Harsh and figurative in style, the thought is profound, making the work difficult to read; even in his own times he was called "the obscure."

Anaxagoras, the friend of Pericles (died 428 B.C.), also wrote on Nature; the fragments still extant afford little guide to his style.

Democritus (died about 370 B.C.) wrote on a variety of subjects; his remains are very scanty, but we know that his manner was vivid and interesting.

Socrates, who gave Athens the position of leader of Greek thought, has come down to us only in the writings of his disciples and through his influence on later philosophers. Of these the first and most illustrious is **Plato** (died 348 B.C.). By instinct a poet, and by training a great thinker, Plato has made his dialogues masterpieces of philosophic writing. In his hands Attic prose reached its acme of lucidity and grace, equally effective in the drawing of character, the expounding of intricate thoughts and the expression of pathos and emotion.

Last of the philosophers of this period comes **Aristotle**, a pupil of Plato, but, as a thinker, of a different school. His writings embrace logic, ethics, metaphysics, and natural science. A master intellect, he set a model of philosophic method which served the civilised world up to the end of the Middle Ages. His style, however, is not equal to his matter. The founder of scientific phraseology, he writes without pretension to elegance or charm. Those who read him do so for the sake of what he has to teach, and not for any intrinsic pleasure to be gained therefrom.

3. The Decline.—After the triumph of Macedon, Athens lost the premier position in Greek literature. The freedom of thought and speech and the sympathy between writer and public that had produced the great tragedians and orators was no more. Congenial surroundings were only to be found in a royal capital, where public order was maintained by troops, and even there the culture demanded of a writer was of a standard so high that pedantry and artificiality were bound to result.

Comedy alone remained enthroned at Athens, but it is a comedy of manners and no longer political or contentious. The New Comedy dates from about 300 B.C. Its plots were those of real life, and the adventures of young gallants, maidens fair and virtuous or otherwise, adventurous and roguish slaves, reflect the stirring times of the successors of Alexander. **Diphilus, Philemon**, and **Menander** are the authors of this class of work whose names have been handed down to us. Their plays survive only in epitomes and in the imitations and adaptations of Roman comedians, but we know that Menander had the greatest reputation, and that the staple theme was love in romantic circumstances.

The literary spirit that left Athens found refuge elsewhere. The conquests of Alexander had spread over Egypt and the East the externals of Greek civilisation. The native population of Alexandria and Pergamos cultivated Greek manners—in the Greek phrase made for the purpose, they "Hellenized"—and the literature which they produced, deriving its inspiration from Greek models and written in the Greek tongue, is called Hellenistic.

Alexandria was the centre of Greek thought from Alexander's time down to the Christian era. Learned men gathered there to use its museum and library, with the result that true Hellenistic literature is rather one of research and scholarship than of sublimity and inspiration. Alexandrian literature reached its most attractive form in the idylls of **Theocritus** (325–260 B.C.). The public, wearied of the material aspect of life in a great city, was drawn by the idea of the delights of country life, and Theocritus created for them an ideal countryside, where shepherds and shepherdesses sang and danced and loved all day beside their flocks. His poems are written with great charm, and those which depict scenes from everyday life, such as one lady paying a call upon another, are wonderfully true and dramatic. He cannot be read, however, without a feeling of artificiality; the very dialects in which he wrote were not his own, but chosen for artistic purposes.

The bucolic tradition of Theocritus was carried on by **Bion of Ionia** and **Moschus of Syracuse**, both in the third century B.C., who, however, lack the power and beauty while they achieve the elegance of their master.

Similarly the epic of **Apollonius Rhodius** (200 B.C.) on the adventures of the Argonauts, though it contains passages of beauty and deep feeling, falls far short of Homer, whom it attempts to follow; its learned allusions and studied construction kill what spontaneity it possesses and make it a typical product of its time.

The true expression, however, of the spirit of Hellenism was found in works of erudition. The poems of **Aratus** (270 B.C.) and **Nicander** (150 B.C.) on astronomy and medicine, and the prose treatises of **Timaeus** (died 256 B.C.), **Polybius** (died 122 B.C.) on history, **Eratosthenes** (*c.* 200 B.C.) on geography, **Aristarchus** (*c.* 150 B.C.) on literary criticism, **Euclid** (*c.* 300 B.C.) on geometry, **Hipparchus** (*c.* 150 B.C.), and **Hermagoras** (*c.* 120 B.C.) on the science of rhetoric, were all monuments of learning and cleverness, and very poor as literature pure and simple.

The Graeco-Roman Period.—The conquest of Greece by Rome once more affected the flow of the tide of Greek literature. Now more than ever original inspiration is sought in vain: Greece produces for the pleasure or education of Rome, with the result that can be imagined.

Some names stand out above the rush of mediocrities and bores. **Meleager of Gadara**, was a poet as well as a scholar, and wrote charming little elegies on love and death that form the basis of the collection of epigrams known as the Greek Anthology.

In prose, history and philosophy are the principal topics. **Plutarch's** *Lives* (A.D. 46–120) are full of charm and interest; perhaps too obviously meant to improve, they have no great value as history, but as sketches of character and means of entertainment they have attained a popularity for all time that few ancient authors have approached.

Quite unlike Plutarch was the earlier work of **Polybius** (205–122 B.C.), who is less read, though of far more value historically. Polybius possesses the true historical sense; in his history of Rome, from 264 B.C. to his own times, he shows a feeling for cause and effect and an appreciation of political exigencies that place him on a level with Thucydides himself. His follower Livy, who owes to him much of his information, is as inferior to him as a historian as he is superior in style; unfortunately the manner of Polybius is not as good as his matter and he makes sadly dull reading.

For the next great name it is necessary to go to the second century A.D. **Lucian**, who wrote about 150, was the author of dialogues in which he assails current ideas about religion, philosophy, and social life. Gifted with keen observation and humour and a vivid imagination, he has always interested and amused a large number of admirers.

Dionysius of Halicarnassus and **Josephus** the historians, **Strabo** and **Pausanias** the geographers, **Longus** and **Heliodorus** the novelists, and **Epictetus** and **Marcus Aurelius** the Stoic philosophers, close that stage in Greek literature which may be called classical. A Christian Greek literature arose restricted to the purposes of the Church. The days of Byzantine power saw a revival, but that falls outside the scope of the present article.

COURSE OF READING

How to Read Greek.—There is an error common among teachers with regard to their Greek reading: they frequently let their pupils begin too soon, and frequently make them begin too late. If he is set to reading too soon, the student begins to read his author with so imperfect a knowledge of word-forms, accidence, and syntax that every other word has to be looked up in a lexicon, with the result that the reader becomes disgusted, and loses all desire to appreciate what he is reading. Under any circumstances, and especially when he is his own teacher, the student should ground himself in grammar and syntax before he begins to read. Properly grounded, he can quickly learn to read and appreciate an author; without that grounding, what should be a labour of love becomes a trial of patience.

The student ought therefore to learn, by heart where possible, the rules for declension and conjugation given above, and to study the article on syntax until he feels acquainted with its principles. It may seem to him to be drudgery, but he will appreciate the soundness of the policy when he comes to his authors.

When he feels sufficiently well grounded, he should begin reading those authors whose style is easiest. *Xenophon*, *Euripides*, *Plato's* Apology, *Homer*, *Demosthenes*, *Sophocles*, is the order in which the first Greek writers should be attempted. When he feels at home with one, the student can go on to the next; and when he is able to read Sophocles with comparative ease, the whole field of Greek literature is open to him.

The bibliography that follows is an attempt to indicate the most suitable editions, and a proper course of reading for a scholar not very far advanced. The prices marked are nett prices in every case.

Besides the translations expressly indicated, nearly every work is translated in the "Tutorial Greek Translations" or in Bell's "Classical Translations," the single volumes averaging from 9*d.* to 3*s.* 6*d.* Bohn's translations also cover the whole field of Greek literature; their prices vary according to the size of the book.

TEXTS

Aeschylus

Agamemnon.
Text and Notes :
Sidgwick. Oxford. 2s. 3d.
Verrall. Macmillan. 10s.

Choephoroe.
Text and Notes :
Sidgwick. Oxford. 1s. 11d.
Verrall. Macmillan. 10s.

Eumenides.
Text and Notes :
Sidgwick. Oxford. 2s. 3d.
Verrall. Macmillan. 10s.
Translation. House of Atreus. Morshead. Golden Treasury Series. 2s. 6d.

Persae.
Text and Notes. Prickard. Macmillan. 1s. 6d.

Prometheus Vinctus.
Text and Notes. Sikes. Macmillan. 1s. 11d.
Translation. Morshead. Macmillan. 1s. 11d.

Seven against Thebes.
Text and Notes :
Verrall and Bayfield. Macmillan. 1s. 11d.
Verrall. Macmillan. 5s. 8d.

The Suppliants.
Text and Notes. Tucker. Macmillan. 9s.
Translation. Swanwick. Bell. 3s. 9d.

N.B.—The large editions by Verrall each comprise a prose translation.

Anthology

Mackail. Select Epigrams. Longmans. 10s. 8d.
Mackail. Select Epigrams. (Text only.) Longmans. 1s. 6d.

Aristophanes

Acharnians. Merry. Clarendon Press. 2s. 3d.
Birds. Merry. Clarendon Press. 2s. 8d.
Knights. Merry. Clarendon Press. 2s. 3d.
Clouds. Merry. Clarendon Press. 2s. 3d.
Frogs. Merry. Clarendon Press. 2s. 3d.
Wasps. Merry. Clarendon Press. 2s. 8d.

Translation :
Frere. (Acharnians, Knights, Birds.) Routledge. 1s.
Rogers. (Separate plays.) Bell. Av. 7s. 6d.

Aristotle

Ethics.
Text and Notes. Hawkins. Longmans. 6s. 9d.
Translation. Welldon. Macmillan. 5s. 8d.

Poetics.
Aristotle's Theory of Poetry. Text, Translation, and Notes. Butcher. Macmillan. 9s. 5d.
Wharton. Text and Translation. Parker. 2s. 6d.
Aristotle's Art of Poetry. Prickard. Macmillan. 2s. 8d.

Politics.
Text and Notes. Susemihl and Hicks. Macmillan. 18s.
Translation. Welldon. Macmillan. 7s. 11d.

Rhetoric.
Text and Notes. Cope. Cambridge. 24s.
Translation. Jebb. Cambridge. 4s. 6d.

Attic Orators

Selections. Jebb. Macmillan. 3s. 9d.

Demosthenes

De Corona. Drake. Macmillan. 2s. 8d.
Leptines. King. Macmillan. 1s. 11d.
Philippic I. Gwatkin. Macmillan. 1s. 11d.
Private Orations. Paley and Sandys. Cambridge. 3 vols. 6s. to 7s. 6d.
Against Conon and Callicles. Swift. Methuen. 1s. 6d.

Translation : Kennedy. Everyman Series.

Introduction to the Study of Demosthenes. Butcher. Macmillan. 1s. 2d.

Euripides

Alcestis. Earle. Macmillan. 2s. 8d.
Bacchae. Tyrrell. Macmillan. 2s. 8d.
Hecuba. Hadley. Cambridge. 1s. 11d.
Hippolytus. Mahaffy and Bury. Macmillan. 1s. 11d.
Medea. Verrall. Macmillan. 1s. 11d.
Troades. Tyrrell. Macmillan. 1s. 11d.

Translation. Way. Macmillan. 4s. 6d.

Euripides the Rationalist. Verrall. Cambridge. 5s. 8d.
Euripides. Ancient Classics Series. Blackwood. 1s. 11d.

Herodotus

Book I. Text and Translation. Woods. Longmans. 4s. 6d.
Book II. Text and Translation. Woods. Longmans. 3s. 9d.
Book III. Text and Notes. Macaulay. Macmillan. 1s. 11d.
Book IV. Text and Notes. Shuckburgh. Pitt Press. 3s.
Book V. Text and Notes. Shuckburgh. Pitt Press. 2s. 3d.

Book VI. Text and Notes. Shuckburgh. Pitt Press. 3s.
Book VII. Text and Notes. Mrs. Butler. Macmillan. 2s. 8d.
Book VIII. Text and Notes. Shuckburgh. Pitt Press. 3s.
Book IX. Text and Notes. Shuckburgh. Pitt Press. 3s.

Translation :
Macaulay. Macmillan. 13s. 6d.
Grant. Murray. 9s.

HESIOD

Text and Notes. Paley. Whittaker. 5s.
Translation. Mair. Clarendon Press. 3s. 6d.

HOMER

Iliad.
Text and Notes :
Books I–XII. Monro. Clarendon Press. 4s. 6d.
Books XIII–XXIV. Monro. Clarendon Press. 4s. 6d.
Translation. Lang, Leaf, and Myers. Macmillan. 9s. 5d.

Companion to the Iliad. Leaf. Macmillan. 5s. 8d.

Odyssey.
Text and Notes :
Books I–XII. Merry. Clarendon Press. 3s. 6d.
Books XIII–XXIV. Merry. Clarendon Press. 3s. 9d.
Translation. Butcher and Lang. Macmillan. 7s. 6d.

Growth of the Homeric Poems. Wilkins. Longmans. 6s.

ISOCRATES

Selections, with Notes. Schneider. 3s.
V.s. Attic Orators.

LUCIAN

Selections, with Notes. Abbott. Longmans. 2s. 8d.
Somnium, Charon, &c. Heitland. Pitt Press. 2s. 8d.
Menippus and Timon. Mackie. Pitt Press. 2s. 8d.
Translation. Six Dialogues. Irwin. Methuen. 2s. 8d.

Lucian. Ancient Classics Series. Blackwood. 1s. 11d.

LYSIAS

Selections, with Notes. Shuckburgh. Macmillan. 3s. 9d.
V.s. Attic Orators.

PINDAR

Text and Notes :
Isthmian and Nemean Odes. Fennell. Pitt Press. 6s. 9d.
Olympian and Pythian Odes. Fennell. Pitt Press. 6s. 9d.
Translation. Myers. Macmillan. 3s. 9d.

PLATO

Apology. Adam. Pitt Press. 2s. 8d.
Crito. Adam. Pitt Press. 1s. 11d.
Euthyphro. Adam. Pitt Press. 1s. 11d.
Protagoras. Adam. Pitt Press. 3s. 5d.
Republic. Adam. Pitt Press. 3s. 5d.

Translations :
Jowett. Clarendon Press. £4, 4s.
Church. (Euthyph., Apol., Crit., Phaed.) Macmillan. 2s. 6d.

Plato and Platonism. Pater. Macmillan. 6s. 4d.

POETS, LYRIC

Lyric Poets. Farnell. Longmans. 16s.
Greek Melic Poets. Smyth. Macmillan. 7s. 6d.

SOPHOCLES

Text and Notes :
Antigone, Oedipus Tyr., Ajax, Philoctetes. Jebb. Pitt Press. Each 3s.
Oedipus Col. Davies. Pitt Press. 3s.
Trachiniae, Electra. Shuckburgh. Pitt Press. Each 3s.
Also an edition, with Notes and Translation, by Jebb. Pitt Press. Each 12s. 6d.

Translation. Campbell. Paul. 7s. 6d.

THEOCRITUS

Text and Notes. Snow. Clarendon Press. 4s. 6d.

Translation :
Lang. Macmillan. 2s. 6d.
Calverley. Bell. 2s.

THUCYDIDES

Books I, II, III. Marchant. Macmillan. Each 2s. 8d.
Books IV, V. Graves. Macmillan. Each 2s. 8d.
Books VI, VII. Marchant. Macmillan. Each 2s. 8d.

Book VIII. Tucker. Macmillan. 2s. 8d.

Translation :
Bohn's Classical Library. Bell. 2 vols. Each 3s. 6d.

Thucydides Mythistoricus. Cornford. Arnold. 10s. 6d.

Xenophon

Anabasis.

Text and Notes :

Books I–IV. Goodwin. Macmillan. 2*s.* 8*d.*

Each book separately. Clarendon Press. 1*s.* 1½*d.*

Text and Translation :

Books I–III. Isbister. Longmans. 2*s.* 8*d.*

Cyropaedia.

Text and Notes :

Book I. Bigg. Clarendon Press. 1*s.* 6*d.*

Books IV and V. Bigg. Clarendon Press. 1*s.* 11*d.*

Memorabilia.

Text and Notes. Marshall. Clarendon Press. 2*s.* 3*d.*

Selections.

Text and Notes. Keene. Macmillan. 1*s.* 2*d.*

As soon as he can understand more or less as he goes on, the student should make a practice of reading aloud, translating in his mind the while. With a proper amount of practice he will find that, except for points of exceptional obscurity, he will be able to translate fluently and idiomatically. If at this stage he tries to render a piece of English into Greek, he will find that, sub-consciously, his mind has stored up the Greek idiom, and can express the English words as a Greek would have expressed them.

Too much reliance should not be placed on translations ; they are useful only for reading over *after the passage has been translated unaided,* to clear up any doubtful points. If used to save the trouble of translating, they will speedily cripple all power of reading.

The following list of books on Greek literature and some of its more important aspects will help the student to a further appreciation of his reading of the texts. Their titles sufficiently explain the point of view from which the books approach the subject, and, while the whole provides a fair course of reading, a student may find it unnecessary and less stimulating to work through the complete list than to select one or two of the more general books, such as Butcher's *Aspects* or Pater's *Studies,* and thoroughly assimilate them.

LITERATURE

Butcher. Some Aspects of the Greek Genius. Macmillan. 7*s.*

Jebb. Primer of Greek Literature. Macmillan. 9*d.*

Schlegel. Dramatic Literature. Bell. 2*s.* 8*d.*

Murray. Greek Literature. Heinemann. 4*s.* 6*d.*

Murray. Rise of the Greek Epic. Clarendon Press. 6*s.*

Jebb. Growth and Influence of Greek Poetry. Macmillan. 7*s.*

Pater. Greek Studies. Macmillan. 7*s.* 6*d.*

Mahaffy. History of Classical Greek Literature. Macmillan. 4 parts. Each 3*s.* 5*d.*

Two good grammars for reference are :

Rutherford.

Accidence. Macmillan. 1*s.* 6*d.*

Syntax. Macmillan. 1*s.* 6*d.*

(In one vol. 2*s.* 8*d.*)

Mansfield.

Greek Syntax. Rivington. 1*s.* 6*d.*

For composition, the student should work through *Hillard and Botting,* and then go over the ground again in *Browne* or *Sidgwick.* Keys should be used for the purpose of correction only, and after correction each exercise should be retranslated without the key. It is important to remember that the only way in which to learn to write Greek is by reading it, and the best matter for reading is the Greek authors themselves.

Hillard and Botting.

Elementary Greek Exercises. Rivington. 1*s.* 11*d.*

Browne.

Handbook to Greek Composition. Longmans. 3*s.*

Sidgwick.

First Greek Writer. Rivington. 2*s.* 8*d.*

Introduction to Greek Prose Composition. (More advanced.) Rivington. 3*s.* 9*d.*

Stuart M. Green, B.A., LL.B.

LATIN

Inflexion

In English, when we wish to express the relation of one word to another, we do so by means of prepositions. Thus, if we desire to associate the two words *king* and *England*, we use the preposition *of* to show the relation in which they stand to one another, and say the *King of England.*

In Latin, such relationship is expressed to some extent by means of prepositions, but, whether a preposition is used or not, words express their relations towards their context by the variety of their forms.

The English language does this to a slight degree in the case of verbs—e.g. *I gave the book* indicates past time, and *I give the book* indicates present time; the essential part of the word *give* is retained in each case, but its form is changed to express a different shade of meaning.

In Latin, nouns, pronouns, adjectives, and verbs are inflected, and the inflexion is of two kinds:

1. Declension of nouns, pronouns, and adjectives.
2. Conjugation of verbs.

Declension

Declension comprises differences according to gender, number, and case.

(a) **Gender.**—In Latin there are three genders: *Masculine, Feminine,* and *Neuter.* The rules governing gender are erratic, but the following three generalisations will form a rough guide.

(i) *Masculine* are names of months, rivers, and winds, and words essentially male in meaning—e.g. ***vir***, a man; ***taurus***, a bull.

(ii) *Feminine* are names of trees, plants, cities, countries, and islands, and words essentially female—e.g. ***mulier***, woman; ***soror***, sister.

(iii) *Neuter* are indeclinable nouns, substantival phrases, and quoted expressions, and very many inanimate objects.

(b) **Number.**—As in English, there are two numbers in Latin, singular and plural.

(c) **Case.**—It is the case that marks the relation borne by a word to the other words that surround it. Thus, in the expression, "There is a tide in the affairs of man," the relation of the word *man* to the word *affairs* is made clear by the possessory preposition *of*. In Latin, that relation is expressed by a variation of the word for *man*, which shows clearly that *man* is a possessive and depends on one of the contiguous words.

There are six cases in Latin, which are generally listed in the following order:

The Nominative, the case of the subject.
Vocative, the case used in speaking to a person.
Accusative, the case of the direct object of a verb—*e.g.* "To wake to ecstasy the living lyre," *the living lyre* is accusative.
Genitive, the case of possession.
Dative, the case of advantage.
Ablative, the case of agency or motion from.

There were also originally a locative and an instrumental case, now merged in the use of the ablative, though the locative is preserved in some names of places and adverbial expressions.

The cases are distinguished by different endings, which again are divided into five different series, known as the Five Declensions. The following table gives at a glance the whole scheme of Latin declension:

	1st Dec.	2nd Dec.	3rd Dec.	4th Dec.	5th Dec.
		Singular.			
		Neut.		Neut	
Nom. *the, a*	-a	-us : um / -er	-s (*originally*)	-us : -u	-es
Voc. *o*	-a	-e, -er „	„	„ „	„
Acc. *the, a*	-am	-um „	-em	-um : -u	-em
Gen. *of*	-ae	-ī	-īs	-ūs	-eī
Dat. *to, for*	-ae	-ō	-ī	-uī	-eī
Abl. *with, by*	-ā	-ō	-e	-ū	-ē
		Plural.			
Nom., Voc.	-ae	-ī : -a	-ēs : -a, -ia	-ūs : -ua	-ēs
Acc.	-as	-ōs : -a	-ēs : -a, -ia	-ūs : -ua	-ēs
Gen.	-arum	-orum	-um, -ium	-uum	-ērum
Dat., Abl.	-īs	-īs	-ibus	-ubus (ibus)	-ēbus

It will be observed that, while in the several declensions the case-endings end generally in the same way, the vowel parts thereof differ regularly, according to the declension. Thus it can be said that

-a is the vowel of the 1st Declension.				
-o	„	„	2nd	„
-ĕ or -ĭ	„	„	3rd	„
-u	„	„	4th	„
-ē	„	„	5th	„

It will also be apparent, on examining the above table, that:

1. Neuter substantives always have nom., voc., and acc. the same. Also their plur. nom., voc., and acc. always end in *-a*.
2. In the 3rd, 4th, and 5th Declensions the nom., voc., and acc. plur. are always the same.
3. The 2nd Declension is the only one in which there is a separate form for the voc. sing.
4. In all the declensions the dat. and abl. plur. are the same.

First Declension

Port-a, *a door*, -am, -ae, -ae, -ā.
Port-ae, *doors*, -ās, -ārum, -īs.

Note.—1. An original gen. form in *-s*, like the 3rd, 4th, and 5th Declensions, is shown in *paterfamilias*, father of a family.
2. The loc. sing. has the *-ae* of the gen.; *Romae*, at Rome.
3. The gen. plur. is sometimes in *-um*, chiefly in compounds of *-cola, -gena*. E.g. *coelicola*, deity, gen. plur. *coelicolum*.
4. The dat. and abl. plur. are found in *-ābus* where it is necessary to distinguish from the 2nd Declension. E.g. *ā deīs*, from the gods; *ā deābus*, from the goddesses.
5. Nouns of this declension are fem., save when males are meant—e.g. *nauta*, a sailor, is masc.

Translate, giving all the possible meanings of: mensae, nautarum, filiabus, filiis, agricolum, rosa reginae, Italiae regina, nautarum puellae, epistula ancillae.

Second Declension

Servus, *slave.*	Serv-us, -e, -um, -ī, -ō, -ō.
Servi, *slaves.*	Serv-ī, -ī, -ōs, -ōrum, -īs, -īs.
Puer, *boy.*	Puer, puer, puer-um, -ī, -ō, -ō.
Pueri, *boys.*	Puer-ī, -ī, -ōs, -ōrum, -īs, -īs.
Ager, *field.*	Ag(e)r, ag(e)r, agr-um, -ī, -ō, -ō.
Agri, *fields.*	Agr-ī, -ī, -ōs, -ōrum, -īs, -īs.
Bellum, *war.*	Bell-um, -um, -um, -ī, -ō, -ō.
Bella, *wars.*	Bell-a, -a, -a, -ōrum, -īs, -īs.

Note.—1. Most of the words in *-ero* and *-ro* drop the *-us* of the nom. sing., and in the case of words in *-ro* make the *-r*, thus left at the end, sound by placing *-e* before it—*e.g.* original *ag-r-os* becomes *ag-r*, and then *ager*.
2. *Deus*, god, is irregular, and has nom. plur. *dī, diī*, and abl. plur. *diīs, dīs*.
3. *-um* is found in the gen. plur. in words meaning measures and weights, and in a few other special cases.
4. The loc. sing. is like the gen., and in the plur. is like the abl.
5. Words ending in *-ius* make their voc. and gen. sing. in *-ī*, not *-iī*.

6. Nouns in *-us* are masculine; nouns in *-um* are neuter; save names of trees, &c., as noted in Gender, Rule (ii) above.

Translate, giving every possible meaning of: līberōrum, caprī, servī dominōrum, puer magistrī, dominī hortus, servī gladiō, bella Romanōrum, dōna virī, humerīs taurōrum, dōnīs deōrum, dominus Aegyptī, Delphīs, fīlī equus, numerus sociōrum, nummos virōrum, hospero, Gaius magister puerōrum, librī Graecōrum.

Third Declension

In this declension, to be able to decline the word it is necessary to know not only the nom. sing., but also the gen. sing., as the nom. generally shows a form of stem that is different from the stem shown in the other cases.

Note that in this declension the nom. and voc. sing., nom., voc., and acc. plur., and dat., abl. plur. form three groups, in which the endings are the same. Consequently only one example will be given for each group.

Vigil, gen. vigil-is, *watchman* (m.)	sing. -em, -is, -ī, -e, plur. -ēs, -um, -ibus.
Mel, mell-is, *honey* (n.)	sing. -is, -ī, -e, plur. -a, -um, -ibus.
Hiems, hiem-is, *winter* (f.)	sing. -em, -is, -ī, -e, plur. -ēs, -um, -ibus.
Homo, homin-is, *man* (m.)	sing. -em, -is, -ī, -e, plur. -ēs, -um, -ibus.
Carmen, carmin-is, *song* (n.)	sing. -is, -ī, -e, plur. -a, -um, -ibus.
Flamen, flamin-is, *priest* (m.)	sing. -em, -is, -ī, -e, plur. -ēs, -um, -ibus.

Note.—1. Nouns in *-l* are masc., save *mel*, and *fel*, bile, which are neut.
2. Nouns in *-en* are neut., save *flamen*, words meaning musicians compounded with *-cen*, and *pectēn*, a comb.
3. Nouns in *-do, -go, -io* are fem., except *cardo*, hinge; *ordo*, rank; *pugio*, dagger; and a few uncommon words. Other nouns in *-o* are masc., except *caro, carnis*, flesh.

Anser, anser-is, *goose* (m.)	-em, -is, -ī, -e, -es, -um, -ibus.
Marmor, marmor-is, *marble* (n.)	-is, -ī, -e, -a, -um, -ibus.
Ebur, ebor-is, *ivory* (n.)	-is, -ī, -e. -a, -um, -ibus.
Iter, itiner-is, *road* (n.)	-is, -ī, -e, -a, -um, -ibus.
Pater, patr-is, *father* (m.)	-em, -is, -ī, -e, -es, -um, -ibus.

Note.—1. Like *pater* are declined *māter*, mother; *frāter*, brother; *accipiter*, hawk.
2. Nouns in *-er* and *-or* are masc., except *arbor*, tree (f.), and words essentially fem., as *soror*, sister, and except the neut. words *iter; cicer*, pea; *piper*, pepper; *marmor; ver*, spring; *cadāver*, dead body; *papāver*, poppy.

3. Nouns in *-ar* and *-ur* are neut., except *solar*, trout; *furfur*, bran; *augur*, augur; and names of animals in *-ur*.

Flōs, flōr-is, *flower* (m.)	-em, -is, -ī, -e, -es, -um, -ibus.
Corpus, corpor-is, *body* (n.)	-is, -ī, -e, -a, -um, -ibus.
Os, oss-is, *bone* (n.)	-is, -ī, -e, -a, *-ium*, -ibus.
As, ass-is, *as* (a coin) (m.)	-em, -is, -ī, -e, -ēs, *-ium*, -ibus.

Note.—1. Nouns in *-is* (gen. *-eris*) and *-ōs* (*-ōris*), are masc., except *ōs*, mouth, neut.

2. Nouns in *-us* (*-eris*, or *-oris*) and *-ūs* (*-ūris*) are neut., except *lepus*, leporis, and *mus*, muris, which are masc.

Pēs, ped-is, *foot* (m.)	-em, -is, -ī, -e, -es, -um, -ibus.
Cor, cord-is, *heart* (n.)	-is, -ī, -e, -a, -um, -ibus.
Dux, duc-is, *leader* (m.)	-em, -is, -ī, -e, -es, -um, -ibus.

Note.—1. Of stems ending in *-d*, *-c*, *-p*, or *-t*, only *cor*; *lac*, lactis, milk; *caput*, capitis, head, are neut. Of the rest, masc. are nouns in *-es*, *-itis*; *-eps*, *-ipis*; and most in *-ex*, *-icis*. Fem. are nouns in *-tus*, *-tutis*; *-tas*, *-tatis*; and most other nouns in *-x*.

2. *Supellex*, furniture, has an irregular stem, supellectil-is.

Finis, fin-is, *limit* (m.)	-em, -is, -ī, -e, -es, -ium, -ibus.
Caedes, caed-is, *slaughter* (f.)	-em, -is, -ī, -e, -es, -ium, -ibus.
Imber, imbr-is, *shower* (m.)	-em, -is, -ī, -e, -es, -ium, -ibus.
Sedile, sedil-is, *stool* (n.)	-is, -ī, -ī, -ia, -ium, -ibus.
Animal, animāl-is, *animal* (n.)	-is, -ī, -ī, -ia, -ium, -ibus.

Note.—1. In these *-i* stems an acc. sing. in *-im* is found in *buris*, plough-beam; *febris*, fever; *pelvis*, basin; *puppis*, poop; *turris*, tower; *restis*, cable; *securis*, axe; *sitis*, thirst; and *tussis*, cough; also with names of cities and rivers.

2. Similarly an abl. sing. in *-ī* is found in all the *-i* stem neuts., save *rete*, net, and also in *turris*, *sitis*, *securis*, *bipennis*, and names of cities, rivers, and months.

3. Nouns in *-er*, *-ris*, are masc., except *linter*. Nouns in *-es*, and most in *-is*, are fem. Nouns in *-al*, *-e*, *-ar*, are neut.

Canis, can-is, *dog* (m.)	-em, -is, -i, -e, -es, -um, -ibus.

Note.—Like *canis* are declined *juvenis*, young man; *senex*, senis, old man; *volucris*, bird.

urbs, urb-is, *city* (f.)	-em, -is, -i, -e, -es, -ium, -ibus.

Note.—Like *urbs* are declined nouns in *-us*, *-utis*; *-rx*, *-rcis*; *-rs*, *rtis*; *-lx*, *-lcis*; also *dōs*, dotis, dowry; *lis*, litis, dispute, *fraus*, fraudis, fraud; *nox*, noctis, night; *nix*, nivis, snow; *fauces*, jaws; also all monosyllables in *-ps*, *-bs*, and nouns in *-ās*, *-is*, *-tās*.

Substantives of this type are generally fem., save a few masc. exceptions, of which the commonest are *mons*, mountain; *fons*, fountain; *pons*, bridge; *dens*, tooth.

Irregular Nouns

The following nouns differ in declension from any of the usual types:

Vīs, vis, *force* (f.)	vim, vis, vi, vī, vīrēs, vīrium, vīribus.
Sūs, su-is, *pig* (m.f.)	suem, suis, suī, sue, suēs, suum, suibus (sūbus).
Bōs, bov-is, *ox*, *cow* (m.f.)	bovem, bovis, bovī, bove, bovēs, boum, būbus (bōbus).
Jupiter, Jov-is, *Jupiter* (m.)	Jovem, Jovis, Jovī, Jove.

Nouns from the Greek

Nouns imported from Greek into the 3rd Declension retain their Greek forms in the nom., acc., voc., and sometimes gen. in the sing, and also in the nom. acc. plur.

Lampas, lampad-os, *torch*	-a, -os (-is), -ī, -e, -ĕs, -ăs, -um, -ibus.

Fourth Declension

Fructus, *fruit* (m.)	fructus, fructum, fructūs, fructuī, fructū, fructūs, fructūs, fructuum, fructibus.
Cornu, *horn* (n.)	cornu, cornūs, cornū, cornū, cornua, cornuum, cornibus.

Note.—1. The dat. abl. plur. end in *-ŭbus* in *arcus*, bow; *tribus*, tribe; *quercus*, oak; and sometimes in *artus*, limb; *lacus*, lake; *partus*, birth; *verū*, spit.

2. *-ū* is the regular dat. sing. ending in neut. words.

3. All nouns ending in *-u* are neut.; all in *-us* are masc., except *acus*, needle; *anus*, old woman; *domus*, house; *Idūs*, Ides; *socrus*, mother-in-law; *nūrus*, daughter-in-law; *tribus*, tribe; *porticus*, porch.

Irregular are:

domus, *house* (f.), domum, domūs(-ī), domī(-ō), domō(-ū); domūs, domōs(ūs), domorum (domuum), domibus.

senātus, *senate* (m.), gen. senatūs(-ī).

Fifth Declension

diēs, *day* (m.), diēs, diem, diēī, diēī, diē; diēs, diērum, diēbus.

Note.—1. The nom., voc., acc. plur. are the same.

2. All nouns in this declension are fem., except *dies* and *meridies*, mid-day, and *dies* is fem. when it means an appointed time.

Translate, giving every possible meaning of: Rex Britanniae, regum insignia, grex ovium, victores pugnā, nomine, divitiae urbis, tribuum

ordo, boum cornibus, rerum relīquiae, Athēnis, virginum caedes, pluvii imber, finis diēī, pater patriae, tribunus mīlitum, capite anseris, equitis calcāria, Jupiter rex et exemplar deorum, finibus tellūris, genera animālium, mel flōrum sanguis, virgo rēgis et rēgīnae fīlia, domi, domus, senatus princeps favore tribuum.

Roots and Stems.—Now that the five declensions have been reviewed, it may be of use to consider some of the difficulties that they present; the 3rd Declension offers the greatest number of apparent anomalies. In order to elucidate these, it is necessary to consider the history of Latin as a language. It is now an accepted fact that Latin is the descendant of an original mother-language, known to scholars as the Indo-European language, to which most of the languages of Europe look back as their common parent. The gap between the parent and the child in the case of Latin is a long one and not easy to bridge over, yet on examination many of the principles that governed the one are apparent in the other, and working on the basis of these it is possible to understand many of the apparent errings from the normal that bewilder the student of Latin.

One of the first peculiarities noticeable in the 3rd Declension is that a number of nouns show forms in the nom. that do not apparently account for the forms of the other cases. Why, for instance, do we find *corpus* and *corporis*, *homo* and *hominis*, *flos* and *floris*? These seeming anomalies render the path of the student hard, whereas to make them plain is not difficult, and the resulting clearness of vision fully rewards the extra time and trouble given to acquiring the knowledge of how to cope with them.

There existed in the original language, and there has largely survived in Latin, a system of word-formation, working more or less on regular principles. The notion of the word was expressed by a root, which is to be found in all the adaptations of the idea. To the root was often added a syllable, or one or two syllables, that brought the root-notion within the more narrow limits of one of the parts of speech; this gives us what is known as the stem. Finally to the stem may be added a case-ending or tense-ending, which assigns to the word its exact grade of meaning.

Take, *e.g.*, the root *opi-*, which expresses the idea of "plenty." To this is added the suffix *-lento-*, which carries an adjectival meaning, and the word is completed by the addition of the case-ending, e.g. *-s*, and we get *opulentus*, a rich man.

Again, from the root *gene-*(= beget) develops *genitor* (= ancestor); *gene-tor* (a noun suffix denoting one who performs the action indicated by the root).

Now, in the case of 3rd Declension nouns, the original rule was that neuter nouns in the nom. appeared as the stem without a case suffix, and with the vowel of the stem suffix as weak as possible.

Thus if the stem ended in *-os*, the nom. would end in *-us*, or if the stem was *-in*, the nom. would end in *-en*. The stronger form of the vowel of the stem suffix would appear normally in the gen., dat., and abl. Hence the forms

corpus—corporis,
semen—seminis.

In masc. and fem. nouns the rule was the reverse, the nom. using the strongest form of the vowel of the stem suffix. Take, for example, the stem *hom-in-*. Originally the root *hom-* (seen in a stronger form in *hūm-anus*) was followed by a sound as of the letter *n* used as a vowel, long or short. In Latin the long form of this vowel was *ōn*, the shorter form was *in*.

Then, remembering the rule that stems ending in *-m*, *-n*, *-l*, *-r* form the nom. masc. or fem. by dropping the final letter, we can understand the declension:

homō(n), hominis, &c.
ordō(n), ordinis, &c.

In *caro(n)*, *carnis*, can be seen the very weakest form of the *-n-* vowel in the oblique cases. Similar vowel gradation is shown in the case of pat*er*, pat*ris*, &c., the original vowel in this case being a vocalised *-r*.

The question then arises, Why does Latin have corp*us* in the nom. and corp*oris*, &c., in the other cases? The answer is that, as a general rule of Latin word-formation, an *-s-* from the original language, when it found itself between two vowels, tended to change to *-r-*. Thus *genus* gives genitive *generis* (orig. gen-es-is), *corpus* gives *corporis* (orig. corp-os-is), *flōs* gives *floris* (flosis), &c.

With the exceptions already noticed, the rule holds good that the nom. masc. and fem. in the 3rd Declension is formed by adding *-s* to the stem or root. Here, again, some peculiarities of Latin require notice. The Latin tongue found it awkward to pronounce the combinations *-ts*, *-ds*, and the result was that, where *-ts*, *-ds* occurred in the original language, in Latin they resolved simply into *-s*. Hence the declension:

Pēs (ped-s), pedem, pedis, &c.
Miles (milet-s), militem, militis, &c.

Another regular way in which consonants changed in Latin is shown by the manner in which *-t*, *-d*, after another consonant, disappear from the end of a noun—*e.g.*:

Original *cord* gives us *cor*, cordis.
„ *lact* „ *lac*, lactis.

So that the rule that the nom. neut. in the 3rd

Declension consists of the stem and nothing more is borne out really, though not apparently.

Assimilation of one sound to another accounts for the following forms:

sedeo, I sit: *sella*, seat (*sed-la*); *ad*, to, *curro*, I run: *accurro*, I run up; *sub*, under, *pono*, I place: *suppono*, I place under, &c.

The last change of importance is that by which *b* and *g* become *p* and *c* before *s* or *t*:

scrib-o, but *scrip*-si,
reg-o, but *rec*-tus.

And *m* becomes *n* before a dental or a guttural:

*prim*us, but *prin*ceps,
eum, but *cun*dem.

Accent

The Latin accent is responsible for some peculiarities in the form of words. In Latin, the accent is one of stress—that is to say, a syllable that is accented is pronounced with more vigour than those which are not accented. This stress-accent is employed according to a well-defined rule, namely:

If the last syllable but one in a word is long, the stress falls on it; if it is short, the stress falls on the syllable before it. In words of two syllables the first is always accented.

The use of a stress-accent has had some effect in word-formation. One of the results is seen in *syncope*.

Syncope—*i.e.* the cutting out of an unaccented syllable—is manifest in the following examples:

(*N.B.*— The sign ʹ represents the accent.)

*árid*us, dry: *ard*órem, heat; *ard*ére, to burn; *pró-vid*ens, seeing ahead: *prúd*ens, prudent; *régo*, direct: (pór*rigo*) pór*go*, proceed; *aévum*, (*aévitas*) *aé*tas, age.

Another result of stress-accent is the tendency for the unaccented vowels to lose their character, as in the case of the last syllable in the English words "fáther," "sister." In Latin this is evident when the following pairs of words are placed side by side:

cápio, ínc*ipit*.
rémum*ágo*, rém*igo*.
pário, pép*eri*.
cáno, céc*ini*.

Adjectives.—The function of an adjective is to add a quality to a substantive; therefore we find in an inflexional language, such as Latin, that an adjective is made to correspond to its noun in number, gender, and case.

Consequently, adjectives must be declined, and in Latin they have case forms similar to substantives, which, according to the stem-characteristic, are of 1st and 2nd, or 3rd Declensions.

Adjectives of First and Second Declensions

Masc, declined (*a*) like *dominus*, or (*b*) like *puer* or *ager*.
Fem., declined like *porta*.
Neut., declined like *bellum*.

A few adjectives of the 1st and 2nd Declensions have in the gen. and dat. sing. the pronominal forms *-ius* and *-i*—*e.g.*:

totus	tota	totum
totum	totam	totum
totīus	totīus	totīus
totī	totī	totī
totō	totā	totō

Similarly declined are *uter*, *alius*, *solus*, *ullus*, *unus*, *alter*, *neuter*.

(*N.B.*—*Alius* has *aliud* in the nom., voc., acc. sing., neut.)

Adjectives of the Third Declension

These have either (*a*) one, (*b*) two, or (*c*) three endings in the nom. sing.

(*a*)

	Singular.		Plural.	
	M. & F.	*N.*	*M. & F.*	*N.*
N., V.	capax		capaces	capacia
Acc.	capacem	capax	capaces	capacia
Gen.	capacis	capacis	capacium	
Dat., Abl.	capaci		capacibus	

Note.—This class includes all stems ending in consonants, also *vetus*, veteris, old. Yet note that the gen. plur. ends in *-ium*, and neut. nom. plur. in *-ia*.

(*b*)

	Singular.		Plural.	
	M. & F.	*N.*	*M. & F.*	*N.*
Nom., Voc.	omnis	omne	omnes	omnia
Acc.	omnem	omne	omnes	omnia
Gen.	omnis		omnium	
Dat., Abl.	omni		omnibus	

	Singular.		Plural.	
	M. & F.	*N.*	*M. & F.*	*N.*
N., V.	minor	minus	minores	minora
Acc.	minorem	minus	minores	minora
Gen.	minoris		minorum	
Dat.	minori		minoribus	
Abl.	minore		minoribus	

Note.—All comparatives are really *-s-* stems, the *-s-* becoming *-r-* between vowels, as in the case of *corpus*. The final *-r* in nom. masc. and fem. is due to analogy.

Note that the comparatives have abl. sing. in *-ĕ*, and neut. nom. plur. and gen. plur. in *-a* and *-um*.

All the adjectives of this class are from stems ending in *-ri-*, the nom. sing. masc. becoming *-er*, thus showing the longest form of the vocalised *-r-*, as in *imber*.

(*c*)

	Singular.			Plural.	
	M.	*F.*	*N.*	*M. & F.*	*N.*
N., V.	celeber	celebris	celebre	celebres	celebria
Acc.	celebrem		celebre	celebres	celebria
Gen.	celebris			celebrium	
Dat., Abl.	celebri			celebribus	

The system of variation between *-i* stem forms and others in abl. sing. and gen. plur., and nom.,

voc., acc. neut. plur. can be best appreciated when made clear by a diagram:

	Abl. Sing.	Gen. Plur.	N. V. A. Neut. Plur.
Adjectives of 3rd Decln. speaking generally:—	-i	-ium	-ia
Exceptions: celer, volucris, coelestis, agrestis, inops, memor, vigil and compounds of pes:—	-i	*-um*	-ia
coeles, compos, particeps, pauper, princeps, pubes, impubes, sospes, superstes, dives:—	*-e*	*-um*	mostly wanting
vetus	*-e*	*-um*	*-a*
All comparatives	-e	-um	-a
Present participles	*-e*, -i[1]	-ium	-ia

[1] The -i form only when used in an adjective sense; *e.g.*: me praesente, but praesenti tempore.

Comparison of Adjectives.—There are, as in English, three degrees of comparison—*i.e.* Positive, Comparative, Superlative; e.g. "*good*" is positive, stating that the quality exists. "*Better*" is comparative, comparing the thing described with something else. "*Best*" is superlative, stating the existence of the quality to its greatest extent.

Regularly in Latin the comparative is formed by adding *-ior*, the superlative by adding *-issimus* to the stem—*e.g.*:

fulvus, *tawny*	fulvior	fulvissimus
audax, *bold*	audacior	audacissimus
amans, *loving*	amantior	amantissimus
tener, *tender*	tenerior	tenerrimus

Note that:

1. In the case of stems in *-er*, the *-s-* of the superlative becomes *-r-*; e.g. *tenerrimus* = tener-simus.
2. Vetus, *old*, has irregular *vetustior* in the comparative.
3. Six adjectives in *-ilis* form the superlative by adding *-limus* to the stem—*e.g.*:

   facilis, *easy* facilior facillimus

   The others are difficilis, similis, dissimilis, gracilis, humilis.
4. Adjectives ending in *-ficus*, *-dicus*, *-volus* are compared like participles in *-ens*:

   beneficus, *beneficent* beneficentior beneficentissimus
5. Adjectives ending in *-us* preceded by a vowel, with the exception of those in *-quus*, compare by means of the words *magis*, more, and *maxime*, most:

   e.g. dubius, *doubtful*; magis dubius; maxime dubius.

N.B.—There are one or two unimportant exceptions to this.

6. Some adjectives show roots or stems in the comparative and superlative different from the positive—*e.g.*:

Bonus, *good*	melior, *better*	optimus, *best*
Magnus, *large*	major, *larger*	maximus, *greatest*
Parvus, *small*	minor, *smaller*	minimus, *smallest*
Multus, *much*	plus, *more*	plurimus, *most*

7. In some words indicating *position* or *order of time or place*, a positive form is lacking, though the stem of the positive may be found in an adverb or preposition:

Citerior, *on this side*.	citimus, *nearest*.	*Cf.* citra, *on this side*.
Prior, *before*.	primus, *first*.	*Cf.* prae, *before*.

Translate, giving every possible meaning of. Bonus rex; multum in parvo; puella magis idonea magno imperatori; imperium optimum omnium donum; Alba Longa Romae urbis mater; ultima dies; postremo die; facilis descensus Averni; homo conscius nequitiae; Regina Parthorum bello ferocissima; bellum utilius Caesari; Ciceronis opera omnia; serpens ingentis magnitudinis.

Adverbs.—1. The usual ending of adverbs derived from adjectives of the 1st and 2nd Declensions is *-e*—*e.g.*:

late, widely, from *latus*; *misere*, wretchedly, from *miser*.

2. The usual ending for adverbs formed from adjectives of the 3rd Declension is *-ter*, *-iter*, added to the stem—*e.g.*:

graviter, *weightily*, from gravis, *heavy*.

3. The next commonest ending is *-tim*, an old accusative form. There are also endings in *-o*, *-um*, *-am*, *-tus*, while, when added to pronominal stems, *-de*, implying direction from, and *-dem*, implying direction towards, are to be found.

Comparison of Adverbs.—The comparative of the adverb is the acc. sing. neut. of the comparative of the adjective. The superlative is formed according to Rule 1 above, from the superlative of the adjective.

e.g. graviter gravius gravissime

Numerals.—There are five classes of Numerals:

1. *Cardinals*, which tell how many there are.
2. *Ordinals*, which tell in which order they come.
3. *Distributives*, which tell how many apiece there are.
4. *Multiplicatives*, which tell how many fold they are.
5. *Numeral adverbs*, which tell how many times a thing happened.

Notation.		Cardinals.	Ordinals.
1	I.	unus, *one*	primus, *first*
2	II.	duo, *two*	secundus, *second*
3	III.	tres	tertius
4	IV.	quattuor	quartus
5	V.	quinque	quintus
6	VI.	sex	sextus
7	VII.	septem	septimus
8	VIII.	octo	octavus
9	IX.	novem	nonus
10	X.	decem	decimus

Distributives.	Multiplicatives.	Numeral Adverbs.
singuli, *one apiece*	simplex, *simple*	semel, *once*
bini, *two apiece*	duplex, *double*	bis, *twice*
terni	triplex	ter
quaterni	quadruplex	quater
quini	quincuplex	quinquiēs
sēni	—	sexies
septēni	septemplex	septies
octōni		octies
novēni		novies
dēni	decemplex	decies

Notation.		Cardinals.	Ordinals.	Distributives.	Multiplicatives.	Numeral Adverbs.
11	XI.	undecim	undecimus	undeni	—	undecies
12	XII.	duodecim	duodecimus	duodeni	—	duodecies
13	XIII.	trēdecim	tertius decimus	terni deni	—	terdecies
14	XIV.	quattuordecim	quartus decimus	quaterni deni	—	quaterdecies
15	XV.	quindecim	quintus decimus	quini deni	—	quinquiesdecies
16	XVI.	sedecim	sextus decimus	seni deni	—	sexiesdecies
17	XVII.	septendecim	septimus decimus	—		
18	XVIII.	duodēviginti	duodēvicesimus	duodeviceni	—	duodevicies
19	XIX.	undēviginti	undevicesimus	undeviceni	—	undevicies
20	XX.	viginti	vicesimus	viceni	—	vicies
21	XXI.	viginti unus (unus et viginti)	vicesimus primus (unus et vicesimus)	viceni singuli	—	semel et vicies
30	XXX.	triginta	tricesimus	triceni	—	tricies
40	XL.	quadrāginta	quadrāgesimus	quadrāgeni	—	quadrāgies
50	L.	quinquāginta	quinquagesimus	quinquageni	—	quinquagies
60	LX.	sexaginta	sexagesimus	sexageni	—	sexagies
70	LXX.	septuaginta	septuagesimus	septuageni	—	septuagies
80	LXXX.	octoginta	octogesimus	octogeni	—	octogies
90	XC.	nonaginta	nonagesimus	nonageni	—	nonagies
100	C.	centum	centesimus	centeni	centuplex	centies
101	CI.	centum et unus	centesimus primus	centeni singuli	—	semel et centies
121	CXXI.	centum viginti unus	centesimus vicesimus primus	centeni viceni singuli	—	centies semel et vicies
200	CC.	ducenti	ducentesimus	duceneni	—	ducenties
300	CCC.	trecenti	trecentesimus	treceneni	—	trecenties
400	CCCC.	quadringenti	quadringentesimus	quadringenteni	—	quadringenties
500	D.	quingenti	quingentesimus	quingenteni	—	quingenties
600	DC.	sescenti	sescentesimus	sescenteni	—	sescenties
700	DCC.	septingenti	septingentesimus	septingenteni	—	septingenties
800	DCCC.	octingenti	octingentesimus	octingenteni	—	octingenties
900	DCCCC.	nongenti	nongentesimus	nongenteni	—	nongenties
1000	M.	mille	millesimus	singula milia	—	millies
1121	MCXXI.	mille centum viginti unus	milles. centes. vices. primus	&c.	—	&c.
2000	MM.	duo milia	bis millesimus	bina milia	—	bis millies
1,000,000	$\overline{|X|}$	deciens centena milia	&c.	&c.	—	&c.

Cardinals, ordinals, multiplicatives, distributives, are adjectives.

Note.—1. Only the first three cardinals are declinable—viz. *unus*, one, f 1st and 2nd Declensions.

Nom.	duo, duae, duo, *two*	tres, tria, *three*
Acc.	duos, duas, duo	tres, tria
Gen.	duorum, duarum, duorum	trium
Dat. Abl.	duobus, duabus, duobus	tribus

2. Ordinals are adjectives of 1st and 2nd Declensions.
3. *Mille* is indeclinable, but has plur. *milia*, which is a noun declined like *tria*. It is used with the gen.—e.g. *duo milia hostium* =2000 of the enemy.
4. Distributives are declined as plurals of 1st and 2nd Declension adjectives, save that gen. plur. is *-um*, except in *singulorum*.
5. Multiplicatives are declined as consonant stem adjectives of the 3rd Declension.

Pronouns

Personal Pronouns

	First Person.		Second Person.	
	Sing.	*Plur.*	*Sing.*	*Plur.*
Nom.	ego, *I*	nos, *we*	tu, *thou*	vos, *you*
Acc.	me	nos, *us*	te, *thee*	vos
Gen.	mei	nostrum, -i	tui	vestrum, -i
Dat.	mihi	nobis	tibi	vobis
Abl.	me	..	te	..

Note.—The gen. plur. ending varies according to the meaning. The ending in *-i* is objective, that in *-um* denotes *a part.*

E.g. *That is our house*, Nostri est illa domus. *Twenty of us are getting ready*, Viginti nostrum se parant.

Third Person

The original personal pronoun of the 3rd person is used in Latin only as a reflexive; in its stead is used the determinative *is, ea, id,* which will be found declined under its proper head.

Reflexive Pronouns

For the 1st and 2nd person there is no separate form, but the forms of the personal pronoun are used with a reflexive meaning—e.g. *me amo*, I love myself; *amatis vos*, you love yourselves.

The 3rd person has a pronoun of its own, which, although declinable, has no distinctions of number or gender.

Acc.	se, sese, *himself, herself, itself, themselves*
Gen.	sui
Dat.	sibi
Abl.	se, sese

Possessives

The personal and reflexive pronouns have each an adjectival form with a possessive meaning.

Thus, to	ego	corresponds	meus
..	tu	..	tuus
..	se	..	suus
..	nos	..	noster
..	vos	..	vester

All are declined as regular adjectives of the 1st and 2nd Declensions, except that the voc. sing. of *meus* is *mi*.

Determinative Pronouns

is=*he, this, it.*

	M.	*F.*	*N.*
	Singular.		
N.	is	ea	id
Acc.	eum	eam	id
Gen.	eius	eius	eius
Dat.	ei	ei	ei
Abl.	eo	ea	eo
	Plural.		
Nom.	ei, ii	eae	ea
Acc.	eos	eas	ea
Gen.	eorum	earum	eorum
D. Ab.	eis, iis	eis, iis	eis, iis

Idem =the same, is really *i(s)-dem*, and is declined accordingly—e.g. *idem, eadem, idem.*

It is only necessary to note that *-m* becomes assimilated to the following *-d*—e.g. *eorundem*, not *eorumdem*.

Demonstrative Pronouns

Hic = *this*. Ille = *that*.

SINGULAR.

	M.	*F.*	*N.*	*M.*	*F.*	*N.*
Nom.	hic	haec	hoc	ille	illa	illud
Acc.	hunc	hanc	hoc	illum	illam	illud
Gen.	huius	huius	huius	illius	illius	illius
Dat.	huic	huic	huic	illi	illi	illi
Abl.	hōc	hāc	hōc	illo	illā	illo

PLURAL.

Nom.	hi	hae	haec	illi	illae	illa
Acc.	hos	has	haec	illos	illas	illa
Gen.	horum	harum	horum	illorum	illarum	illorum
D., Ab.	his	his	his	illis	illis	illis

Like *ille* is declined *iste* = that of yours.

Note.—*Hic*, *iste*, and *ille* correspond to the 1st, 2nd, and 3rd persons respectively. *Hic* means "this here by me," *iste* means "that there by you," and *ille*, "that there by him."

The Intensive Pronoun

The intensive pronoun *ipse* = self, as its name implies, intensifies the force of a noun or pronoun—e.g. *Ipse veniam* = I myself will come; *Ipsa Minerva volet* = Minerva herself will wish it.

Its declension is precisely the same as that of *ille*, save that the nom. sing. neut. ends in *-um*, and not in *-ud*.

The Relative Pronouns

Qui = who, is declined as follows:

	SINGULAR. *M.*	*F.*	*N.*	PLURAL. *M.*	*F.*	*N.*
N. V.	qui	quae	quod	qui	quae	quae
Acc.	quem	quam	quod	quos	quas	quae
Gen.	cuius	cuius	cuius	quorum	quarum	quorum
Dat.	cui	cui	cui	quibus	quibus	quibus
Abl.	quo	quā	quo			

Quicunque, whoever, has the *qui* declined as above. *Quisquis*, anyone, has both parts declined like *quis* below.

The Interrogative Pronouns

Quis = who? is declined like *qui*, except for the nom. sing. masc. and fem. which make *quis*, and the nom. and acc. sing. neut., which make *quid*.

Quisnam = who, pray? and *ecquis* = anyone? decline the *quis* as above.

Uter = which of two? and *utercunque* = whichever of two, decline *uter* as an adjective of the 1st and 2nd Declensions.

Indefinite Pronouns

The principal pronouns under this heading are *quis* and its compounds. It is only necessary to remember that they are used both in a substantive and in an adjective sense, and that, generally speaking, their nom. sing. forms vary between those of *quis* and those of *qui* respectively. Thus, *vidi aliquid* = I saw something, but *aliquod vulnus te accepisse necesse est* = you must have received some wound.

The Verb

Verbs, like nouns, are in Latin subject to inflexion, which in their case is called Conjugation. By means of conjugation are expressed:

1. *Person* and *Number*.
2. *Voice*—*Active* or *Passive*.

The Active Voice shows that the action of the verb proceeds from the subject—*amo*, I love.

The Passive Voice shows that the action of the verb is directed towards the subject—*amor*, I am loved.

Note.—Some verbs are only found in one voice. Of these, some again are passive in form, but active in meaning. Such are called *Deponents*.

3. *Tense*:

Present, Imperfect, Future,
Perfect, Pluperfect, Future Perfect.

The *Present* tense denotes the existence of a fact and the continuance of an action at the moment of speaking, as, "I am here," "He is walking."

The *Future* denotes what will happen at a time later than the moment of speaking: "He will tell us to-morrow."

The *Perfect* in its pure sense denotes an action or state of things begun in the past and completed at the moment of speaking—*e.g.* "I have eaten my dinner," *i.e.* "I began to eat it, and went on eating, and now, at the time when I speak, it is actually all eaten."

The *Future Perfect* denotes that at some time in the future the subject of the verb will be able to say, "I have done so and so," e.g., *cras abiero*, to-morrow I shall have gone away.

These tenses are known as Principal Tenses.

The remaining tenses, which are known as Historical, are:

The *Imperfect*, which denotes that at a specified time in the past an action was being carried on, or a state of things was continuing to exist. *e.g.* "He was for three years in charge of the office," or "I used to like listening to him."

The *Aorist Perfect*, denoting the plain fact that at a point of time in the past a thing was done or an occurrence took place—*e.g.* "He was killed." "The horse ran away."

The *Pluperfect*, denoting that at a moment in the past an action or state of things which had begun before then was at an end—*e.g.* "When he was found he had given up hope."

Note.—In form the Aorist and Pure Perfects are identical.

4. *Mood*—*Indicative*, *Subjunctive*, *Imperative*.

The Indicative Mood states a fact: *amo*, I love.

The Imperative is the mood of command: *abi*, go away.

The Subjunctive represents an idea, or something that exists only in a dependent sense: *ut amem*, so that I may love; *si amarem*, if I were to love. It has only four tenses—Present, Imperfect, Perfect, and Pluperfect.

The three moods make up what is known

as the Finite Verb. There are also in the verb-system forms akin to nouns classed as the Verb Infinite. They are as follows:

The *Infinitive*, which is related to the nouns, and denotes action or condition in general—*e.g.:*

pugnare, *to fight;* pugnavisse, *to have fought.*

The *Gerund* is a verbal substantive declined like neuters of the 2nd Declension. Its oblique cases are used to supply the want of them in the infinitive—*e.g.:*

Ars pugnandi, *the art of fighting.*

The *Gerundive* is an adjective, attaching to the noun it qualifies the idea of the verb.

The *Supine* shows the accusative and ablative of a verbal noun:

Horrescit relatu, *he shudders at the telling.*

The *Participles* have partly the nature of verbs and partly of adjectives, and are, besides the gerundive, three in number:

Active Present: amans, *loving.*
Active Future: amaturus, *about to love.*
Passive Perfect: amatus, *loved.*

The Formation of the Verb.—Conjugation, like declension, consists in affixing various endings to the stem to express various shades of meaning. In the case of a fully inflected verb there are three principal stems:

1. The *Present Stem*, on which are based: (Active and Passive.)
   - (*a*) The present, imperfect, and future of all moods.
   - (*b*) The present infinitive.
   - (*c*) The present participle.
   - (*d*) The future participle and the gerund.
2. The *Perfect Stem*, on which are based: (Active.)
   - (*a*) The perfect, pluperfect, and future perfect.
   - (*b*) The perfect infinitive.
3. The *Participial Stem*, on which are based: (Passive.)
   - (*a*) The perfect participle.
   - (*b*) The perfect, pluperfect, and future perfect indicative.
   - (*c*) The perfect and pluperfect subjunctive.
   - (*d*) The perfect infinitive.

On this stem (3) also are apparently formed the supine, future active participle, and future infinitive, active and passive.

The inflexion of verbs falls into four conjugations, distinguished by the ending of the present stem. As this ending is always apparent unmodified in the *present infinitive*, that is chosen as the most convenient means of determining the conjugation.

Conjugation.	*Present Stem Ending.*	*Infinitive.*
1	-a	-āre
2	-ē	-ēre
3	-e *or* -o	-ere
4	-ī	-īre

Thus to be able to conjugate a verb it is necessary to know the present stem, perfect stem, participial stem, and present infinitive active, and therefore these are always cited as the *principal parts* of a verb:

1. *The Present Indicative* (1st person singular). (Active.)
2. *Present Infinitive.* (Active.)
3. *Perfect Indicative* (1st person singular). (Active.)
4. *Past Participle Passive* (nom. sing. neut.).

Note.—If there is no past participle passive, the supine is cited, or, in the absence of a supine, the future participle active.

The endings characteristic of the various persons are as follows:

	Active.		Passive.	
	Sing.	*Plur.*	*Sing.*	*Plur.*
1.	-o, -m	-mus	-r	-mur
2.	-s	-tis	-ris, -re	-mini
3.	-t	-nt	-tur	-ntur

Note.—The perfect indicative active has its own endings:

	Sing.	*Plur.*
1.	-ī	-mus
2.	-stī	-stis
3.	-t	-ērunt (*or* ēre, *poetical*)

Before proceeding to deal with conjugation at length, it is necessary to give first the verb *sum*, I am, an irregular verb, which enters as an auxiliary into the inflexion of the regular verbs.

Principal Parts

Pres. Ind.	Infin.	Perf. Ind.	Fut. Partic.
sum	esse	fui	futurus

Indicative Mood.		Subjunctive Mood.	
	Present		
sum, *I am*	sumus, *we are*	sim	simus
es, *thou art*	estis, *you are*	sis	sitis
est, *he, she, it is*	sunt, *they are*	sit	sint
	Imperfect		
eram, *I was*	eramus		essemus
eras	eratis		essetis
erat	erant	esset	
	Future		
ero, *I shall be*	erimus		
eris	eritis		
erit	erunt		
	Perfect		
fui, *I have been, or I was*	fuimus	fuerim	fuerimus
fuisti	fuistis	fueris	fueritis
fuit	fuerunt	fuerit	fuerint
	Future Perfect		
fuero, *I shall have been*	fuerimus		
fueris	fueritis		
fuerit	fuerint		
	Pluperfect		
fueram, *I had been*	fueramus	fuissem	fuissemus
fueras	fueratis	fuisses	fuissetis
fuerat	fuerant	fuisset	fuissent

Imperative Mood

es, *be thou*	este, *be ye*
esto, *thou shalt be*	estote, *ye shall be*
esto, *he shall be*	sunto, *they shall be*

Infinitive

Pres. esse, *to be*
Perf. fuisse, *to have been*
Fut. futurus esse, *to be about to be*

Participle

Fut. futurus, *about to be*

Note.—There also occur:

Imperf. subj. forem, fores, foret, forent
Fut. Inf. fore

The Four Conjugations

Active

	I		II		III		IV	
				Indicative				
Present Stem.								
Present	-o -ās -at	-āmus -ātis -ant	-eo -ēs -et	-ēmus -ētis -ent	-o -is -it	-imus -itis -unt	-io -īs -it	-īmus -ītis -iunt
Future	-ābo -ābis -ābit	-ābimus -ābitis -ābunt	-ēbo, &c.		-am -ēs -et	-ēmus -ētis -ent	-iam -ies, &c.	
Imperfect . . .	-ābam -ābas -ābat	-ābāmus -ābātis -ābant	-ēbam &c.		-ēbam &c.		-iēbam &c.	
Perfect Stem								
Perfect	-āvi -āvisti -āvit	-āvimus -āvistis -āvērunt	-ui -uisti, &c.		-i -si -vi -ui } &c.		-īvi &c.	
Future Perfect . .	-āv-ero -āveris -āverit	-āverimus -āveritis -āverint	-uerim &c.		-erim &c.		-īverim &c.	
Pluperfect . . .	-āv-eram -āveras -āverat	-āverāmus -āverātis -āverant	-ueram &c.		-eram &c.		-īveram &c.	
				Subjunctive				
Present Stem.								
Present	-em -ēs -et	-ēmus -ētis -ent	-eam -eās -eat	-eāmus -eātis -eānt	-am -ās -at	-āmus -ātis -ant	-iam -ias, &c.	
Imperfect . . .	-ārem -ārēs -āret	-ārēmus -ārētis -ārent	-ērem -ērēs &c.		-erem -eres &c.		-īrem -īres &c.	
Perfect Stem								
Perfect	-āv-erim -āveris -āverit	-āverimus -āveritis -āverint	-uerim &c.		-erim &c.		-iverim &c.	
Pluperfect . . .	-avissem -avisses, &c.		-uissem &c.		-issem &c.		-īvissem &c.	
				Imperative				
Present Stem.	-ā -āto -āto	-āte -ātōte -anto	-ē -ēto -ēto	-ēte -ētōte -ento	-e -ito -ito	-ite -itōte -unto	-ī -īto -īto	-īte -ītōte -iunto
				Infinitive				
Present . . . . Perfect . . . . Future	-āre -avisse -āturus esse		-ēre -uisse -iturus esse		-ere -isse -turus esse *or* -surus esse		-īre -īvisse -īturus esse	
				Participle				
Present . . . . Future	-ans -aturus		-ens -iturus		-ens -turus *or* -surus		-iens -iturus	
				Gerund				
	-andum -ī -o		-endum &c.		endum &c.		-iendum &c.	

Passive

To form the passive *present* stem, indicative and subjunctive tenses, *i.e.* present, future, and imperfect indicative and subjunctive, it is merely necessary to substitute for the active endings :

-o *or* -m	-mus
-s	-tis
-t	-nt,

the passive endings :

-or	-mur
-ris	-mini
-tur	-ntur

Thus, if the future indicative active of *audio* is :

audiam, -es, -et ; -emus, -etis, -ent,

the passive will be :

audiar, -eris, -etur ; -emur, -eminī, entur.

The passive *perfect* stem tenses in the indicative and subjunctive are formed by using the past participle passive, together with the following tenses of *sum* :

		Indic.	*Subj.*
In the	Perfect	sum	sim
„	Fut. Perf.	ero	
„	Pluperf.	eram	essem

Thus the 1st person plural pluperfect of *rego* will be *recti essemus.*

The infinitive passive is as follows :

Conj.	I	II	III	IV
Pres.	-āri	-ēri	-ī	-īri
Perf.	-ātus esse	-itus esse	-tus *or* -sus esse	-ītus esse
Fut.	-ātum īri	-itum īri	-tum *or* -sum īri	-ītum īri

The imperative is :

I		II		III		IV	
-āre	-āminī	-ēre	-ēminī	-ere	-iminī	-īre	-īminī
-ātor		-ētor		-itor		-ītor	
-ātor	-antor	-ētor	-entor	-itor	-untor	-ītor	-iuntor

The *Gerundive* is *-ndus* added to the present stem.

An analytical examination of the above tables of forms shows the following aids to verb inflexion :

1. The future indicative in conjugations 1 and 2 ends in *-bo* ; in conjugations 3 and 4 in *-am.*
2. Imperfect subjunctive can always be formed by adding *-m* to the present infinitive.
3. In the passive imperative the 2nd person singular is the same as the present infinitive active.
4. The 3rd person plur. imperative active is 3rd plur. indicative active+*o*.

The tables only show the commonest type in each conjugation. Below are given the principal parts of each of the various types of regular verbs. It will be noted that the 3rd conjugation shows the largest variety.

First Conjugation.—Perfect in *-avi.*

amo, *love* amare amavi amatum
N.B.—But poto, *drink*, has potum

Perfect in *-ui.*

cubo, *lie* cubare cubui cubitum
N.B. But seco, *cut*, has sectum

Perfect in *-i*, with lengthened root-vowel.

lavo, *wash* lavare lavi lautum, lotum

Reduplicated perfect.

sto, *stand* stare steti statum

Second Conjugation.—Perfect in *-ui.*

moneo, *warn* monere monui monitum

Perfect in *-ui*, and past participle in *-tus* (*-sus*).

doceo, *teach* docere docui doctum
censeo, *estimate* censere censui censum

Perfect in *-si.*

augeo, *increase* augere auxi auctum

Perfect in *-vi.*

repleo, *fill* replere replevi repletum

Reduplicated perfect.

tondeo, *shear* tondere totondi tonsum

Perfect in *-i*, with lengthened root-vowel.

video, *see* videre vidi visum

Third Conjugation.—*A.* Present formed by adding *-o* to root.

Perfect in *-si.*

rego, *rule* regere rexi rectum

Note.—With few exceptions whenever the root ends in a mute consonant.

Perfect in *-ui.*

molo, *grind* molere molui molitum

Reduplicated perfect.

cado, *fall* cadere cecidi casurus

Perfect in *-i*, without lengthening.

verto, *turn* vertere verti versum

Perfect in *-i*, with lengthened root-vowel.

Ago, *drive*, *do* agere egi actum

Perfect in *-īvī.*

peto, *seek* petere petivi petitum

B. Where the present stem is formed by reduplication of the root.

sisto (si-sto), *set* sistere stiti statum
gigno (gi-gno), *beget* gignere genui genitum
sero (si-so), *sow* serere sevi satum
bibo (bi-bo), *drink* bibere bibi —

C. Where the present stem inserts a nasal after the root-vowel, as is manifest from the past participle or perfect stem.

Perfect in *-si.*

fingo, *mould* fingere finxi fictum

Reduplicated perfect.

tango, *touch* tangere tetigi tactum

Perfect in *-i*, with lengthened root-vowel.

fundo, *pour* fundere fūdi fusum

Perfect in *-i*, without lengthening.

findo, *split* findere fidi

Perfect in *-ui.*

recumbo, *lie down* recumbere recubui recubitum

D. Present in *-no* and *-llo* (from *-lno*).

Perfect in *-vi.*

cerno, *see* cernere crevi cretum

Reduplicated perfect.

pello, *drive* pellere pepuli pulsum

Perfect in *-si.*

contemno, *despise* contemnere contempsi contemptum

E. Present in *-to.*

flecto, *bend* flectere flexi flexum

F. Present in *-sco.* Primary verbs.

cresco, *grow* crescere crēvi crētum

Inchoatives (*i.e.* verbs describing a process) in *-esco.*

calesco, *grow hot* calescere calui ——

In *-isco.*

dormisco, *fall asleep* dormiscere dormīvi ——

In *-asco.*

vesperasco, *grow dusk* vesperascere vesperāvi ——

G. Present in *-esso.*

capesso, *seize* capessere capessīvi capessītum

H. Present in *-uo.*

Perfect in *-ui.*

statuo, *set up* statuere statui statutum
ruo, *rush* ruere rui ruiturus

Perfect in *-xi.*

struo, *build* struere struxi structum

I. Present in *-io.*

Perfect in *-i*, with lengthened root-vowel.

facio, *make* facere fēci factum

Perfect in *-si.*

aspicio, *look at* aspicere aspexi aspectum

Perfect in *-īvi.*

cupio, *desire* cupere cupīvi cupītum

Perfect in *-ui.*

rapio, *seize* rapere rapui raptum

Reduplicated perfect.

pario, *give birth to* parere peperi partum

Fourth Conjugation.—Perfect in *-īvi.*

audio, *hear* audīre audīvi audītum

Perfect in *-si.*

vincio, *bind* vincīre vinxi vinctum

Perfect in *-ui.*

aperio, *open* aperīre aperui apertum

Perfect originally reduplicated.

reperio, *find* reperīre repperi repertum

Perfect in *-i*, with lengthened root-vowel.

venio, *come* venīre vēni ventum

Irregular Verbs.—Compounds of *sum.*

These are conjugated like *sum*, with the exception of

possum, *I can* posse potui

Note.—*Possum* (potis-sum) in its present system follows *sum*, dropping the *-s-* and substituting *-t-* before vowels—e.g. *poteram*, I was able.

In its perfect system it is conjugated as belonging to an obsolete form, *poteo*, of the 2nd Conjugation.

volo, *wish.* nōlo, *be unwilling.* mālo, *prefer.*

Present

Indic.	*Subj.*	*Indic.*	*Subj.*	*Indic.*	*Subj.*
volo	velim	nolo	nolim	malo	malim
vis	velis	nonvis	nolis	mavis	malis
vult	velit	nonvult	nolit	mavult	malit
volumus	velimus	nolumus	nolimus	malumus	malimus
vultis	velitis	nonvultis	nolitis	mavultis	malitis
volunt	velint	nolunt	nolint	malunt	malint

Imperfect

volēbam vellem nolēbam nōllem malēbam māllem

Future

volam nolam malam
-ēs, -et, &c. -ēs, -et, &c. -ēs, et, &c.

The perfect system is formed on a perfect in *-ui.*

Infinitive

velle	nolle	malle
voluisse	noluisse	maluisse

Participle

volens nolens

Fero, *bear.*

Principal parts : *fero, ferre, tuli, lātum.*

Pres. Ind. : fero, fers, fert, ferimus, fertis, ferunt. All the other forms are regularly based on the principal parts, except 2nd person sing. imperative, *fer.*

Eo, *go.*

Principal parts : *eo, īre, ii, itum.*

	Indicative.		*Subjunctive.*	
Pres.	eo	īmus	eam	eāmus
	īs	ītis	eās	eātis
	it	eunt	eat	eant
Fut.	ībo			
Imperf.	ībam		īrem	
Perf.	ii	iimus	ierim	
	īsti, iisti	īstis, iistis		
	iit, īt	iērunt		
Fut. Perf.	iero			
Pluperf.	ieram		īssem	

Imperative.		*Infinitive.*	*Participle.*	*Gerund.*
ī	īte	Pres. īre	Pres. iens (genitive euntis, &c.)	eundum
īto	ītote	Perf. īsse, iisse	Fut. itūrus	
īto	eunto	Fut. iturus esse		

Fīo, *become.*

Fīo acts as the passive of *facio*, make, in the present system. In the perfect system, and in the gerundive, the forms of *facio* are used.

	Indicative.		*Subjunctive.*	
Pres.	fīo	—	fīam	fīāmus
	fīs	—	fīas	fīātis
	fīt	fīunt	fīat	fīānt
Fut.	fīam, -ēs, -et, &c.			
Imperf.	fīēbam		fierem	

	Imperative.		*Infinitive.*
Pres.	fi	fite	fieri

Edo, *eat.*

Principal parts : *edo, edere, ēdi, ēsum.*

ACTIVE

	Indicative.		*Subjunctive.*	
Pres.	edo	edimus	edim, -am	edimus, -amus
	ēs	ēstis	edis, -ās	editis, -ātis
	ēst	edunt	edit, -at	edint, -ant
Fut.	edam			
Imperf.	edēbam		ēssem	

	Imperative.		*Infinitive.*	*Participle.*
Pres.	ēs	ēste	ēsse	edēns
Fut.	ēstō	ēstōte	ēsurus esse	ēsūrus
	ēsto	edunto		

PASSIVE

Pres. Indic. 3rd. pers. sing.	ēstur
Imperf. Subj. ,, ,, ,,	ēssētur

The perfect system is regular.

Dō, *give.*

Principal parts : *do, dare, dedī, datum.*

ACTIVE

	Indicative.		*Subjunctive.*	
Pres.	dō	damus	dem	dēmus
	dās	datis	dēs	dētis
	dat	dant	det	dent
Fut.	dabo			
Impf.	dabam		darem	
			&c.	

Defective Verbs.—*Aio,* say, has only the following forms :

Pres. Indic.	aio, ais, ait, aiunt.
Pres. Subj.	aiās, aiat.
Imperf. Indic.	aiēbam, -ās, -at, -āmus, -ātis, -ant.
Imperative.	ai. Participle. aiēns.

Inquam, say, has the following forms :

Pres. Indic.	inquam, inquis, -it, -imus, -itis, -iunt.
Imperf. ,,	inquiēbat Perf. Indic. inquii, inquisti.
Fut. ,,	inquiēs, inquiet. Imper. inque, inquito.

Fārī, speak, has :

Pres. Indic.	fātur (-fāmur in compounds)
Imperf. ,,	(-fābar, -fābantur in compounds)
Fut. ,,	fābor, fābitur (-fābimur in compounds)
Perf. ,,	fātus sum, &c.
Pluperf. ,,	fātus eram, &c.
Imper.	fāre
Infinitive.	fārī
Pres. Part.	fāns
Perf. Part. Pass.	fātus
Gerundive.	fandus
Gerund.	fandī, fandō
Supine.	fātū

Meminī, *remember ;* ōdī, *hate ;* coepī, *begin.*

These three verbs, while Perfect in system, are Present in meaning. But *memini* has imperative *memento, mementote,* and *odi* has future participle *osurus.*

Impersonal Verbs

Some verbs occur only in the 3rd person singular and infinitive, and are used impersonally :

The commonest are :

licet, *it is allowed.*	decet, *it is fitting.*	libet, *it is pleasing*
miseret, *it is pitiful.*	ninguit, *it snows.*	pluit, *it rains.*
oportet, *it is necessary.*	pudet, *it shames.*	taedet, *it disgusts.*
tonat, *it thunders.*		

Prepositions.—The only part of speech remaining that may present any difficulty is the *preposition.* In Latin, prepositions govern, some the accusative, some the ablative case—*i.e.* the noun depending on them falls into one of those cases ; *e.g.* :

ad urbem veni, *I came to the city.*
ex Oriente lux, *light from the East.*

The following prepositions govern the accusative :

ad, *to.*	contrā, *against.*	pōne, *behind.*
adversus, *against, opposite to.*	extrā, *outside.*	post, *after.*
ante, *before.*	infrā, *beneath.*	praeter, *beside.*
apud, *among.*	inter, *between.*	propter, *because of.*
circā, circiter, circum } *around, about.*	intrā, *within.*	secundum, *according to.*
	juxtā, *beside.*	suprā, *above.*
	ob, *on account of.*	trans, *across.*
citrā } *this side of.*	penes, *in the power of.*	ultra, *beyond.*
	per, *through.*	versus, *towards.*

The following govern the ablative :

a, ab, *from, by.*	coram, *in the presence of.*
absque, *without.*	cum, *with.*
clam, *unknown to.*	sine *without.*
palam, *in sight of.*	de, *from, concerning.*
ex, e, *out of, from.*	prae, *before, in front of.*
pro, *before, for.*	tenus, *as far as.*

The following govern either case according to meaning :

	Accusative.	*Ablative.*
in,	*into, to, against ;*	*in, among, on.*
sub,	*up to;*	*under.*
subter,	*underneath;*	*close to.*
super,	*over;*	*upon.*

Translate, giving every possible meaning of : Rex vēnit ; milites pugnabunt ; mox adveniet ; fiat justitia, ruat coelum ; puellae cecinerint ; lampada trādā ; vox populi terribilis est ; quid facis, o demens ? nocte abiērunt ; Caesar nonvult regnare ; maluistis domi manēre ; omnium assensu proelium inceptum erat ; Juno amatur ; monēre ; audiebamini ; amari dulce est ; quis non meminit ? recumbere coeperat ; cavēto ; tulisset ; mala non ferenda ; horribile dictu ; oblivisci malum est ; servi vincti erunt ; porta aperta ; fac ; sol caluit ; ipse ruet ; ipse rueris. Quis, talia fando, temperet a lacrimis ?

Syntax, or the Use of Words

Syntax is the science of the use of words in sentences.

Sentences are either *Simple* or *Compound.*

Simple Sentences.—A simple sentence has two parts :

1. The *Subject :* the person or thing about which something is stated.
2. The *Predicate :* that which is stated.

Thus, in the sentence, *Pompeius signum dedit,* Pompey gave the signal, *Pompeius* is the subject, and *signum dedit* is the predicate.

The *Subject* must be one of the following:

1. A *Substantive*: *rex*, the king.
2. A *Substantive Pronoun*: *ego*, I.
3. An *Adjective, Participle*, or *Adjective Pronoun* concealing a hidden noun: *audax*, a bold man; *iratus*, an angry man; *ista*, that woman of whom you were speaking.
4. A *Verb Noun*: *decorum est pro patria mori*, to die for one's country is a noble thing.

Note.—A personal pronoun as subject is usually implied in the verb, and is not separately expressed—e.g. *loquor*, I speak. But for the purpose of emphasis the pronoun is expressed—e.g. *ego loquor et tu audis*, I speak and you hear.

The *Predicate* must be a verb, or a group of words containing and centring round a verb:

Cicero advenit, *Cicero arrived. Advenit* is predicate.

Princeps oratorem ex omnibus disertissimum laudavit, *the emperor praised the most eloquent orator of them all.* From *oratorem* to *laudavit* is predicate.

Agreement.—A *Verb* agrees with its subject in Number and Person:

Haec tria sunt, *these things are three.*
Romani vincunt, *the Romans conquer.*

An *Adjective* or *Participle* agrees with the noun it qualifies in *Number, Gender*, and *Case*:

Magnam partem dividunt, *they divide a large part.*

The *Relative Pronoun* agrees with its antecedent in Gender, Number, and Person; in Case it follows the construction of the clause of which it is part:

Quis est homo quem video? *who is the man I see?*

Te sequor, qui fortis es, *I follow you, who are strong.*

A *Noun* agrees in number, and, where possible, in gender:

1. In apposition to another noun.

Juno, Jovis conjunx, *Juno, the wife of Jove.*

2. When predicative of another noun after the verb *sum* or some similar verb:

Croesus non semper mansit rex, *Croesus did not always remain king.*

Note.—1. When two or more nouns jointly are the subject, verbs and adjectives agreeing with them are generally in the plural:

Romulus et Remus abierunt, *Romulus and Remus went away.*

2. If the persons composing such a subject are different, agreement is with the first person rather than the second, and with the second rather than the third:

Si tu et Cicero id cupitis, ego et Caesar cupimus, *if you and Cicero desire this, Caesar and I desire it.*

3. When the genders are different, adjectives show a preference for the masculine:

Antonius Aegyptiacque regina profecti sunt, *Antony and the Queen of Egypt set out.*

4. Where all the nouns denote inanimate things, the adjectives are neuter:

Amor et dementia consanguinea sunt, *love and madness are kin.*

The Cases.—*Nominative*, the case of the Name.

The subject of a finite verb is in the nominative case:

Fortuna fortes adjuvat, *fortune favours the brave.*

Vocative, the case of Address.

The vocative or nominative used as vocative stands isolated from the rest of the sentence, without any place in its construction:

Infandum, regina, jubes renovare dolorem, *Unspeakable, O queen, is the pain thou biddest me renew.*

Accusative.—The Latin accusative expresses three main ideas:

1. Limitations of time and space.
2. Adverbial relations.
3. Direct object.

I. *Limitations of Time and Space.*

1. *Duration of time:*

Quinque et viginti annos natus, *twenty-five years old.*

Abhinc tres annos, *three years ago.*

2. *Extent of space:*

Arbores quinquaginta pedes altae, *trees fifty feet high.*

3. *Motion towards* a thing or place.

(*a*) The accusative alone is used with names of towns and small islands, and with *domum* and *rus*:

Romam veni, *I came to Rome.*
Rus ibo, *I shall go to the country.*

(*b*) In the case of other words a preposition is used:

Ad castra fugerunt, *they fled to the camp.*

II. *Adverbial Relations.*

1. *Accusative showing degree*, in adjectives and pronouns in the neuter:

Multum sunt in venationibus, *they are much occupied in hunting.*

Maximam partem severus erat, *for the most part he was stern.*

2. *Accusative borrowed from Greek* (misnamed accusative of respect).

Generally used with words expressing parts of the body :

Tremit artus, *he trembles in his limbs.*
Mentem pressus, *overwhelmed in mind.*

III. *Accusative of Direct Object.*

The *direct object of a transitive verb* is in the accusative case :

Exegi monumentum, *I have wrought a monument.*

Fabius in suam provinciam exercitum reduxit, *Fabius led his army back into his own province.*

Verbs of *making, saying, thinking,* &c., have a second accusative agreeing with the object :

Illi me comitem misit, *he sent me to him as companion.*

Urbem Romam vocavit, *he called the city Rome.*

Verbs of *saying, thinking, perceiving,* &c., may have as their object an accusative followed by an infinitive of which it is the subject:

Scio te Romanum esse, *I know you are a Roman* (lit. *I know you to be a Roman*).

Dixit se nuper venisse, *he said he had lately come* (lit. *He said himself to have come lately*).

A similar construction is found with impersonal verbs :

Taedet nil praeter coelum videre, *it is wearisome to see nought but the sky.*

Some verbs of *teaching, asking, concealing* take two accusatives, one of the person, the other of the thing :

Hoc solum te rogo, *this one thing I ask you.*
Nihil nos celat, *he conceals nothing from us.*

Intransitive verbs sometimes take as object an accusative noun with meaning similar to their own :

Somniare somnium, *to dream a dream.*
Stadium currit, *he runs a race.*

Note.—This is the construction known as the cognate accusative.

Translate :—Ruit per urbem. Revenit sub murum. Duxit milites trans pontem. Quot annos Romae eras ? Vincta manus. Te mitem praebuisti. Longam vivere vitam. Hoc unum vos rogabo. Sentiunt se morituros esse. Nego me adfuisse. Dicunt se Caesarem vidisse. Scio Ciceronem disertum esse oratorem. Pueros docebat versūs componere. Boadicea nuda pectus negat se talia diutius passum iri. Quod dixi, dixi. Istius libri primam paginam perlexi, sed nolo te putare me talia amare. Patriae leges sacrae esse debent. Augur consulem monet hostes mox adfuturos esse. Multa timeo. Cicero se timidum praestitit.

Genitive.—The genitive is the case which, speaking generally, translates the English word "of."

Thus, it is used :

A. *To define :*

Hoc regis nomen, *this name of king.*

So to denote authorship :

Iste liber Platonis est, *that book of yours is by Plato.*

Words containing the idea of *accusing, condemning, convicting,* or *acquitting* take a genitive of the offence :

Ambitus accusare, *to accuse of bribery.*
Impietatis absolutus, *acquitted of blasphemy.*

B. To indicate *possession :*

Amici Caesaris, *Caesar's friends.*

Hence the idiom in which the genitive is used impersonally with such a verb as *est,* to denote something that is characteristic :

Imbecilli animi est superstitio, *superstition is a mark of a weak mind.*
Judicis est, *it is the duty of a judge.*
Audacis animi est, *it requires a bold spirit.*

Under this head may be placed the use of the genitive of pronouns and words denoting persons after adjectives meaning *like, common,* &c. :

Viri propria est fortitudo, *bravery is characteristic of a man.*
Mei similis est, *he is like me.*

C. *To denote Quality.*

1. Denoting an attribute of a person or thing :

Vir excellentis ingenii, *a man of distinguished ability.*

Ingentis magnitudinis serpens, *a serpent of enormous size.*

2. Denoting measure :

Exilium decem annorum, *an exile of ten years.*
Murus decem pedum, *a wall ten feet high.*

3. To denote indefinite value, *tanti, quanti, pluris, minoris, parvi, magni, plurimi, minimi, maximi,* are used predicatively :

Sunt jurgia tanti ? *does railing amount to so much ?*

And the first four are used with verbs of buying and selling to denote indefinite price :

Frumentum tanti fuit, *corn was so dear.*

D. *Partitive Genitive.*

I.e. the genitive of a whole, of which parts or a part are distinguished:

Quis deorum? *who of the gods?*
Dimidium facti qui coepit habet, *he has half done the work who has begun it. (Well begun is half done.)*

E. *Objective Genitive.*

I.e. where the genitive is a person or thing acted on by the noun on which it depends, rather than acting upon it:

Hoc maximum periculorum incitamentum est, *this is the greatest encouragement to confront danger.*

Thus *amor parentum* can mean either "love towards . . . ," or "love felt by one's parents."

Under this head may be placed the use of the genitive with adjectives signifying *desire, knowledge, recollection, fear, participation,* and their opposites, together with adjectives in *-ax* formed from verbs, and many participles used adjectivally:

Avidus pecuniae, *greedy of money.*
Beneficii immemor, *apt to forget a kindness.*
Antiquitatis peritus, *learned in archæology.*
Circus capax populi, *a circus big enough to hold a nation.*
Officii negligens, *neglectful of duty.*

Akin to the objective genitive is the use of the genitive *of the thing which* after *obliviscor,* forget; *memini,* remember; *reminiscor,* recollect; *admoneo* and *commoneo,* remind; *misereor* and *miseresco,* pity; and Impersonal Verbs of Feeling, such as *piget, pudet, taedet, miseret,* and *paenitet.*

Officii sui commonere, *to remind (a man) of his duty.*
Taedet me desidiae, *I am tired of sloth.*
Miserere mei debent, *they ought to pity me.*

Translate: Statuam auri dedicavit. Ille equus regis est. Metus deorum magnam partem hominum regit. Oblitus es iter plenum periculorum esse. Quanti libros vendidisti? Tantae molis erat Romanam condere gentem. Furti accusatus judicem praeteritae amicitiae admonet. Timor deorum. Viginti annorum bellum. Satis industriae quis habet? Deorum oblivisci nefas est.

The Dative.—Dative of indirect object, i.e. the case of the person or thing to whom anything is told or given.

This dative is used with many intransitive verbs signifying *pleasing, helping, sparing, pardoning, appearing, speaking, believing, obeying*:

Si illa tibi placet, *if she is pleasing to you.*
Bonis nocet qui malis parcit, *he harms the good who spares the bad.*
Amicis confido, *I trust my friends.*
Regi haec dicito, *tell this to the king.*
Praedam militibus donat, *he presents the booty to the soldiers.*

Verbs of this class are used in the passive only impersonally:

Pio generi parcitur, *the pious race is spared.*
Mihi invidetur, *I am envied.*
Caesari paretur, *Caesar is obeyed.*

A similar dative is used after many verbs compounded with the prepositions:

ad, ante, ab, sub, super, ob,
in, inter, de, con, post, and prae.

Subvenisti homini jam perdito, *you have come to the help of a man who is already lost.*
Consiliis interdum fortuna obstat, *Fortune sometimes opposes our plans.*
Praesentia confer praeteritis, *compare things present with things past.*

The use of the dative after adjectives implying *nearness, fitness, likeness, help, kindness, trust, obedience,* or their opposites, is akin to the idea of the indirect object:

Illi par in belligerando, *his equal in warfare.*
Mihi amicissimus, *most friendly to me.*

Note.—The following take genitive or dative: *communis,* common; *proprius,* proper.

The following take dative more usually, but genitive sometimes: *affinis,* akin; *alienus,* foreign; *par,* equal; *sacer,* sacred. *Similis,* like, generally takes genitive.

Dative of Reference.—This use of the dative denotes the person *to whom a statement refers, of whom it is true,* or *to whom it is of interest:*

Intercludere hostibus commeatum, *to cut off the supplies of the enemy.*

Akin to this dative is the use familiarly known as the *Ethic Dative,* which is used in the case of personal pronouns to suggest *concern* or *interest* on the part of the person denoted:

Quid mihi Celsus agit? *what is my Celsus doing?*
Sit mihi orator tinctus litteris, *our orator should have a smattering of culture.*

Dative of Agency.—The dative is used to denote agency regularly with the gerundive:

Vobis erit videndum, *you will have to see to it.*
Carthago Romanis delenda est, *Carthage must be destroyed by the Romans.*

Also, less freely, with the past part. pass.:

Civis formidatus Othoni, *a citizen dreaded by Otho.*

Dative of Possession:

Est mihi hoc consilium, *I have this plan.*
Roma, tibi quot sunt cives? *O Rome, how many citizens hast thou?*

Dative of Purpose.—This use of the dative denotes *the object prompting an action*, or *the purpose of a thing's existence :*

Canem tibi praesidio relinquam, *I will leave the dog as a guard for you.*
Exemplo est magni formica laboris, *the ant is an example of great industry.*

This construction is used in a special idiom with the gerundive :

Decemviri stlitibus judicandis, *decemvirs for judging disputes.*

Dative of Direction.—This use is solely poetical:

It clamor coelo, *the shout rises to heaven.*

Translate : Imperator mihi dixit, "dā pecuniam mulieri." Castris aggerem circumdedit. Rex innocentibus favet. Quomodo tibi persuadebo ? Cohorti praeest. Judicis est justitiam favori anteponere. Medicinus ei morbum deminuit. Plato mihi maximus est philosophorum. Quis mihi honorem detrahet ? Uxor tibi est amanda. Longum iter militibus faciendum est. Viginti homines praesidio relicti sunt. Cui bono est ? Mox Caesar tibi veniet auxilio. Dictatorem creaverunt hostibus expellendis. Urbs Romae proxima. Haec arma pugnae idonea sunt.

Ablative.—The Latin ablative comprises the uses of three cases originally distinct in form and meaning :

The Ablative or *from*-case.
The Instrumental or *with*-case.
The Locative or *where*-case.

A. *Genuine Ablative.*

Separation.—Verbs of *freeing, depriving, lacking*, and their corresponding adjectives take the ablative, as also the adverb *procul*, far from :

Populum metu liberat, *he frees the people from fear.*
Leva me hoc onere, *relieve me of this burden.*
Curis liberatus, *free from cares.*

Note.—Compounds of *dis-* and *sē-* require a preposition with the ablative :

Dissentio a te, *I differ from you.*

Ablative of Comparison.—The ablative is used with comparatives as a substitute for *quam*, than, with the nominative or accusative :

Natu Catullo major est, *he is older than Catullus.*
Neminem Lycurgo utiliorem Sparta genuit, *Sparta bore no son more useful to her than Lycurgus.*

Ablative of Source.—Chiefly used with the participles *natus* and *ortus :*

Nate deā, *O goddess-born !*

Note.—Pronouns regularly require *ex :*

E quo natus ? *sprung from whom ?*

Ablative of Agent.—The ablative with *ab* is used to denote the *personal agent :*

A Bruto interfectus, *slain by Brutus.*

B. *Instrumental Ablative.*

1. To denote *means :*

Hastā vulneratus, *wounded by a spear.*

The ablative is used in this grade of meaning with *utor*, use ; *fruor*, enjoy ; *fungor*, perform ; *potior*, get possession of ; *vescor*, eat.

Libris utitur, *he uses his books* (lit. *he benefits himself by his books*).
Pane vescor, *I eat bread* (lit. *I feed myself by means of bread*).

Similar is the use of the ablative with *opus est*, there is need :

Quid opus est verbis ? *what need is there of words ?*

The same sense is apparent in the use of the ablative :

(*a*) With *nitor*, lean on ; *innixus*, leaning on ; and *fretus*, supported by.

Fretus virtute, *relying on courage* (lit. *supported by*).

(*b*) With verbs denoting *to consist of :*

Venis et nervis et ossibus continentur, *they are made up of veins, sinews, and bones.*

(*c*) With verbs denoting *exchanging, mixing, accustoming*, or *joining :*

Pace bellum mutavit, *he has exchanged war for peace.*
Virtus pulchritudine conjuncta, *virtue joined with beauty.*

(*d*) With *facio* and *fio :*

Quid fecisti scipione ? *what have you done with the stick ?*

(*e*) With verbs and adjectives of *plenty, fulness*, and *possession :*

Villa abundat gallinā, *the farm abounds in poultry.*
Omni culpa carens, *free from any blemish.*

Note.—But *plenus*, full, more usually takes the genitive.

2. To denote *cause :*

Coeptis immanibus effera Dido, *Dido driven mad by her awful deeds.*

Hence the use with verbs denoting *mental states*, as

delector, *I am pleased.* glorior, *I glory.*
gaudeo, *I rejoice.* fido, *I trust.*
laetor, *I am glad.* confido, *I trust.*
contentus, *satisfied.*

Illum, quo antea confidebant, metuunt, *him in whom they trusted once, they fear.*

3. To denote *attendant circumstances:*

(*a*) Personal manner:

Cum elephanti facie puer natus est, *the boy was born with an elephant's face.*

Silentio evasit, *he slipped away in silence.*

(*b*) Outside circumstances:

Exercitum duarum cohortium damno deducit, *he leads his army back with a loss of two cohorts.*

(*c*) With *cum*, with, to denote accompaniment:

Cum Caesare omnis spes salutis absumpta est, *with Caesar died all hope of safety.*

4. To denote *description.*

In this sense the ablative is used with an adjective in agreement with it:

Summā virtute adulescens, *a youth of high courage.*

Eximiā formā est, *she is of exceptional beauty.*

5. To denote *degree of difference:*

Dimidio minor quam Britannia, *smaller by half than Britain.*

Paucis ante diebus, *a few days before.*

6. To denote *price.*

With verbs of *buying* and *selling:*

Vendidit hic auro patriam, *this man sold his country for gold.*

7. To denote that *in respect to which* something is or is done:

Major natu, *older* (i.e. *greater as to age*).
Minor natu, *younger.*
Eloquentiā ceteris praestitit, *he surpassed the rest in eloquence.*

Under this head comes the use of the ablative with *dignus*, worthy, and *indignus*, unworthy:

Supplicio digni, *deserving of punishment.*

8. *Ablative Absolute.*—This is a phrase consisting of a noun and a participle or another noun in the ablative case. It is independent of the construction of the rest of the sentence; hence the name *Absolute.*

It has the force of a dependent clause and thus may denote:

1. *Time.*

Natus est Augustus consule Cicerone, *Augustus was born when Cicero was consul.*

2. *Condition.*

Te duce, vincemus, *if you are leader, we shall win.*

3. A state of things in spite of which something happened.

Paucis defendentibus oppidum expugnare non potuit, *though the defenders were few, he could not take the town.*

4. *Manner:*

Incitato equo se hostibus obtulit, *he set spurs to his horse and charged the foe.*

C. *Locative use of the Ablative.*

Place where is regularly denoted by the ablative with a preposition:

Corpus in via repertum est, *the body was found in the road.*

Place whence is denoted in the same way:

Ab Africa cras redibit, *he will return tomorrow from Africa.*

But in both these senses
(*a*) Names of towns and small islands;
(*b*) Domo, ruro;
(*c*) Any ablative in poetry
are used without a preposition.

Time at which:

Idibus Martiis accidit, *it happened on the Ides of March.*

Time within which:

In decem annis quater consul fuerat, *he had been consul four times in ten years.*

Note.—The preposition *in* is necessary:
(*a*) with words denoting *time of life* or *office*, unless qualified by an adjective; thus:

In pueritiā, *in boyhood;* but prima pueritia, *in early boyhood.*

In consulatu, *in his consulship;* but quarto consulatu, *in his fourth consulship.*

(*b*) In phrases expressing situation:

In tali tempore, *at such a season.*

(*c*) After a numeral adverb:

Ter in anno, *three times in the year.*

Translate: Nemo nobili genere ortus potest honestate carere. Vir sapientiā vacuus. Fatis desertus ab Africā cum decem servis rediit. Caesar a Bruto pugione interfectus est. Quid melle dulcius, quid leone fortius est? Nemo qui carne vescitur potest vitā frui. Coelum

monte quodam fretum est. Quid meā Tulliolā fiet? Proelio victus urbem militibus complet. Gaudeo Romanorum victoriis. Bonis auspiciis profecti sunt. Pater fili virtute gloriatur. Suā sponte pecuniam reddiderat. Equum ēmi singulari velocitate. Judaeā captā, Titus revēnit. Sole oriente volucres canere coepērunt. Vere resplendent columbae. Jove adverso victor revenit. Omni pecuniā absumptā, nobis laborandum est. Passis crinibus deorum altaria petunt. Londinio profectus triginta diebus ad Africam pervenit. Tertiā horā adero. Haustus ter in die sumendus.

Case Construction with Impersonal Verbs.—*Miseret, piget, paenitet, pudet, taedet,* take an accusative of the person and genitive of the cause:

Miseret me alienorum injuriorum, *I pity the injuries of others.*

Decet, dēdecet, take an accusative of the person with an infinitive as predicate:

Te decet haec dicere, *it becomes you to say this.*

Libet, licet, liquet, contingit, convenit, evenit, expedit, take a dative of the person:

Ne libeat tibi quod non liceat, *let not that please you which is not allowed.*

Interest, it is of importance, it concerns, takes the genitive of the person or thing concerned, save in the case of the possessive pronouns, when it takes the ablative feminine:

Hoc plebis interest, *this concerns the common people.*
Multum vestrā interest, *it concerns you much.*

Refert, with the same meaning as *interest,* is used in the same way, save that the construction with the genitive is rare.

Pertinet, attinet, take the accusative with *ad:*

Quid ad me attinet? *what does it concern me?*

Oportet is used with the accusative and infinitive, or with the subjunctive alone:

Oportet loquamur, *we must speak.*
Hanc scire oportet filia tua ubi sit, *this woman must know where your daughter is.*

Translate: Taedet me tot imitatorum. Pudet eum pigritiae. Multum Caesaris interest hoc scire. Parum te decet tales libros legere. Cuivis licet suum servum punire. Haud meā interest Caesarem Gallos vixisse. Oportet nos id solum facere quod bonis civibus licet. Multum ad regem attinet populum legibus parēre. Mox paenitebit me clementiae. Quid nostrā refert Lesbiam ā Catullo amari?

Uses of Adjectives. *Position.*—In prose the natural position for the adjective in Latin is after the word it qualifies, unless it is desired to emphasize it.

There are cases of set phrases depending for their meaning on the position of the adjective—*e.g.:*

mensa secunda = *a second table.*
secunda mensa = *dessert.*

Adjectives are often used alone in the sense of substantives, thus

Boni can mean *good men.*
Bonae „ „ *of a good woman.*
Bona „ „ *goods.*

Superlatives expressing order or sequence in time or space are often used to denote a part of the noun that they qualify—*e.g.:*

Primo vere, *at the beginning of spring.*
Media nocte, *in the middle of the night.*

The *Comparative* is used where English would use the positive after another comparative followed by *quam:*

Divitior est quam cultior, *he is more rich than polished.*

The *Superlative* is used with *quam* to express the utmost possible limit:

Hominem quam mitissimum interfecisti, *you have killed a man who was as gentle as a man can be.*
Partem quam maximam tibi donabo, *I will give you the largest part I can.*

Translate: Omnes boni mediā nocte dormiunt. Mulierem formosiorem quam pudentiorem amare stultissimi est. Pueri poma quam maxima capiunt. Athenienses Socratem hominem quam sapientissimum veneno interierunt. Maxima pars bonorum tuorum igne consumpta est. Dei fortes homines diligunt.

The Use of Pronouns.—The reflexive pronoun *se,* and its possessive *suus,* are used in all clauses.

A. When reference is made to the *grammatical* subject of the clause:

Miles se ipse interfecit, *the soldier slew himself.*
Si se telo defenderet fur, *if the thief should defend himself with a weapon.*
Hoc sibi nomen adrogat, *he assumes this name.*
Litteras ad se ab amico missas produxit, *he produced letters sent to him by a friend.*

B. When reference is made to a *logical* subject:

Sui colligendi hostibus facultatem relinquunt, *they allow the enemy the opportunity to collect themselves.*
Jusso magistro equitum abdicare se magistratu, *when the Master of the Horse had been bidden to depose himself from his office.*

Suus is idiomatically used in conjunction with *quisque*, each:

Suam quisque puellam malit, *each man prefers his own sweetheart.*
Suum cuique donum dabo, *I will give each man a separate gift.*

As Latin has no reciprocal pronoun to express the idea of "one another," use is made of the periphrasis "*inter se.*" The following examples will explain its use:

Puellae inter se amant, *the girls love one another.*
Romani et Carthaginienses inter se odio sunt, *the Romans and Carthaginians are hateful to one another.*
Rem inter se disputant, *they discuss the matter with one another.*
Munera inter se donant, *they give one another rewards.*

The relative pronoun *qui, quae, quod* always refers to a noun or pronoun which is called the *antecedent.*

Thus, in the sentence *homo quem vidi*, the man whom I saw, *homo* is the antecedent.

The antecedent is sometimes omitted in Latin:

Qui deos veneratur nil timet, *he who worships the gods fears nothing.*

The relative pronoun is used sometimes with the meaning of *talis*, such:

Qui meus amor in te est, *such is my love towards you.*
Quae tua natura est, *such is your disposition.*
Qua es diligentia, *such is your diligence.*

The relative is also used at the beginning of a clause where English would use a demonstrative pronoun with a conjunction, thus:

Res loquitur ipsa, quae valet plurimum, *the thing speaks for itself, and this is of great weight.*
Caesari haec nuntiata sunt, qui statim profectus est, *this was told to Caesar, and he set out at once.*

Note.—The relative is never omitted in Latin, as it is sometimes in English. Thus "the man I saw" is always *homo quem vidi.*

Quis, anyone, is the weakest of the indefinite pronouns. It is almost always used after *si*, if; *nisi*, unless; *ne*, lest; *num*, whether.

Rogat num quis venerit, *he asks whether anyone has come.*

Aliquis, someone, is more definite than *quis:*

Aut ipse occurrebat aut aliquos mittebat, *he would either come to meet him himself or send somebody.*

Quidam, a certain one, is the most definite of all:

Quidam ex militibus, *a certain soldier.*
Quidam ex his ad Nervios pervenerunt, *some of these got through to the Nervii.*

Quisquam, anyone, is very general in its meaning:

Estne quisquam omnium mortalium? *is there anyone of all mortal men?*

Quisque, each one, is used idiomatically as follows.

1. With superlative adjectives:
   Piissimus quisque tyrannum odit, *all the most pious men hate a tyrant.*
   Fortissimus quisque bello cecidit, *all the bravest fell in the war.*
2. With *suus* (cf. *sub* Reflexives).
3. With ordinal numerals.
   Septimus quisque filius, *every seventh son.*

Translate: Mulier se in flumen praecipitavit. Si quis se interficit. Suo cuique judicio utendum est. Exercitui diem primam quamque dicit. Nec quisquam tantum audet adire virum. Excessērunt urbe quidam, alii mortem sibi conscīvērunt. Quod tuum ingenium est, doctissimum quemque Graecorum superavisti. Tiberius spectaculis quae ab aliquo ederentur, quam rarissime interfuit. Nisi quis advenerit, abibo. Optime vivit qui omnia amat. Haec reginae dixi, quae nihil locuta est. Ne saucio quidem sui recipiendi facultas dabatur. Omnino est amans sui virtus.

Syntax of the Verb. *Indicative Mood, Present Tense.*—The present tense represents three grades of meaning:

1. What happens at the present time:
   Amo te, *I love you.*
2. What is continuing to happen at the present time:
   Ambulo, *I am walking.*
3. What is true at all times:
   Fortuna fortes adjuvat, *Fortune helps the brave.*

It has also a specialised use with *jam*, and other words of similar meaning, to indicate something that began in the past and is still going on:

Jamdudum est intus, *he has been indoors for a long time (and is there now).*

In narration, when it is desired to make the account especially vivid, the present tense is used for the past, more particularly by the

historians. This use is known as the Historic Present.

Dumnorigi custodes ponit, *he set guards over Dumnorix.*

Cf. English, "Although you knew he was there, you go and do a silly thing like that."

The present tense is also used to indicate an attempted action:

Censeat is qui poenam removet, *let him who is for removing the penalty express his opinion*—i.e. *who is trying to remove.*

Future Tense.—The future expresses:

1. What will take place.
2. What will be in the course of taking place.

In foro ambulabo, *I shall walk in the forum*, or *I shall be walking in the forum.*

In expressing future time, Latin is far more exact than English, taking care to denote, by the use of different tenses, the precise order in time of the actions they express. Thus: "If I tell them this, they will be annoyed," becomes in Latin, *Si haec illis dixero, irascentur*, which means literally, "If I shall have told them this, &c." The Latin mind saw that the "telling" must precede the "becoming annoyed" which is to result from it, and expresses that fact by the use of the future perfect.

Similarly, where English says, "The man who kills Caesar will have to be brave," Latin has *Oportebit fortem esse eum qui Caesarem occidet*, or literally, "He who shall kill Caesar will have to be brave"—*i.e.* "He will have to be brave at the time when he shall in the future kill Caesar."

Similarly, "I shall go away before you come" is in Latin, *Abiero antequam venies.*

Imperfect Tense.—The primary sense of the imperfect is to denote what was happening at a moment in the past:

Ibam forte via sacra, *I was going by chance along the Holy Way.*

Akin to this sense is the meaning of doing a thing repeatedly in the past:

Equos verberabat, *he kept on whipping his horses.*

Abhinc decem annos pila ludebam, *ten years ago I used to play ball.*

The imperfect is also used like the present with *jam* and similar words to indicate something that was happening at a given moment and had then been happening for some time:

Jamdudum flebam, *I had been weeping for a long time.*

Another use in which the imperfect resembles the present is in denoting an attempt to do something:

Quid faciebas? *what were you trying to do?*

Perfect Tense.—The Perfect Tense has two grades of meaning:

1. *Perfect.* *Scripsi*, I have written.
2. *Aorist.* *Scripsi*, I wrote.

Quid hodie fecisti? *what have you done today?*

Quid heri fecisti? *what did you do yesterday?*

Future Perfect Tense.—The future perfect denotes an act that will, at a certain future time, be completed:

Cras abiero, *by to-morrow I shall have gone.*

For the use of the future perfect in expressing relations of time, *cf.* further the notes on the future tense

Pluperfect Tense.—This tense indicates that an act was, at a time in the past, completed:

Caesar milites pugnare jusserat, sed illi nolebant, *Caesar had ordered the soldiers to fight, but they were not willing to do so.*

Note.—In letters, what are known as *Epistolary* tenses are often used—that is to say, the writer uses a tense which is more suited to the time of reading the letter than to the time of writing it; *e.g.*:

Cum hanc epistolam scribebam, sol occidebat et aves jam tacuerant, *as I write this letter the sun is setting, and the birds have already ceased to sing.*

Translate, giving every possible meaning of: Pompeius abiit priusquam Caesar Romam advēnerat. Si non properabis occasionem praetermittes. Ut puto, deus fio. Conticuērunt omnes intentique ora tenebant. Obsides per tres dies interrogabat. Puer nutricem amabam. Hostes nostros progredi frustra prohibebant. Villam Puteolis jam decem annos habeo. Cum mortuus erit, tibi scribam. Nihil habebam quod scriberem, neque enim novi quidquam audieram. Dum vitat taurum, in fossam cadit. Jam diu cupio Romam visere. Virtus homines optime conservat. Antequam vēnisti, te venientem audieram.

Subjunctive Mood.—In independent sentences the subjunctive is used in the following grades of meaning:

1. To express *Command.*

Stet porta aperta, *let the door stand open.*
Precemur, *let us pray.*

Under this head come the following special idioms:

(*a*) *Ne* with the 2nd person of the perfect subjunctive:

Ne hoc feceris, *do not do this.*

(b) The use of the historical tenses, generally in the 2nd person, to denote what should have been done in the past:

Vera locutus esses, *you should have spoken the truth.*
Romam ires, *you should have been going to Rome.*

2. To express *Wish.*

Sit tibi terra levis, *may the earth lie lightly on thee.*

Hence the idiomatic use of the subjunctive with *utinam:*

Utinam venisses, *would that you had come.*

3. To express *Doubt.*

Quid faciam? *what am I to do?*
Quid facerem? *what was I to do?*

4. To express a *Condition.*

Pluros amicos sic habeas, *in this way you would have more friends.*
Caesari non paream, *I would not obey Cæsar.*

Translate, giving every possible meaning of: Sit imperator clemens. Milonis gladium ne contempseris. In proelio mortem oppetisses. Istum librum mihi monstres. Quid faceret Antonius? Inter se pugnent. Illum regis patrem esse crederes. Ne sit servus procax. Utinam de negotio destitisset. Jovis aedem ineamus. Ego, mehercle, non dubitem. Coelum augur observet. Aquam potius quam vinum biberes.

Imperative.—The imperative mood expresses *command:*

Dic mihi, quid agis? *tell me what are you doing.*

The forms in *-to, -tote,* are especially used when the command is to do something in the future or generally, and so they are always employed in the text of laws.

Duo consules sunto, *let there be two consuls.*

Prohibition is expressed by the imperative *noli* with the infinitive: *noli me tangere,* touch me not.

Also, with a more abrupt force, by the use of *ne* with the perfect subjunctive, commented on above.

Infinitive.—The commonest use of the infinitive is *Prolative—i.e.* to complete the construction of other verbs. The verbs taking the infinitive are:

Verbs of *knowing, teaching, learning:*

Mox discetis mala pati, *you will soon learn to bear troubles.*
Philosophia docet non timere mortem, *philosophy teaches not to fear death.*

Verbs of *wishing, intending:*

Certe statuerat non adesse, *he had certainly decided not to be present.*
Cato servire quam pugnare mavult, *Cato prefers to be a slave rather than to fight.*
Stoicus esse voluit, *he wished to be a Stoic.*

Verbs of *custom, duty, ability:*

Nihil in occulto agere soleo, *I am accustomed to do nothing underhand.*
Debes hoc scribere, *you ought to write this.*
Proelio adesse nequibat, *he was unable to be present at the battle.*

Verbs of *beginning, trying, continuing, hastening,* and their opposites:

Cum ver esse coeperat, *when it began to be spring.*
Frustra mihi subvenire conamini, *in vain do ye try to aid me.*
Illud jam mirari desino, *I am already ceasing to wonder at that.*

The Passive of verbs of *saying* and *thinking:*

Lucullus dicitur pavonum linguas edisse, *Lucullus is said to have eaten peacocks' tongues.*

The past tenses of the infinitive are used in Latin in a manner different from the English idiom after verbs denoting *ability, duty,* &c. The following table will illustrate how in Latin the past tense is conveyed by the principal verb, where in English it would have been contained in the infinitive.

I ought to do this, debeo hoc facere.
I ought to have done this, debebam hoc facere.
I could have done this, potui hoc facere.

Potui hoc fecisse thus means, "I could at that time have had this completed."

Accusative and Infinitive.—The tenses of the infinitive follow the sense—that is to say, if the infinitive expresses what was happening at the time of the principal verb, the present infinitive is used; if it expresses what had happened at the time of the principal verb, the perfect infinitive is used; if it expresses what was still to happen at the time of the principal verb, the future infinitive is used. Thus:

Intelligo eum venturum esse, *I understand he will come.*
Intelligebam eum venturum esse, *I understood he would come.*
Intelligebam eum venire, *I understood he was then coming.*
Intelligo eum venire, *I understand he is now coming.*
Intelligo eum venisse, *I understand he came.*
Intelligebam eum venisse, *I understood he had come.*

The infinitive is used as the subject of impersonal verbs and verbs used impersonally:

Forsan et haec olim meminisse juvabit, *perhaps one day it will give us pleasure to remember these things.*

Curae est scire Caesarem abiisse, *it is an anxiety to know that Caesar has departed.*

Gerund and Gerundive.—The gerund is a verbal noun, and so is used in some noun constructions as follows.

The *Genitive* is used idiomatically with *causā* and *gratiā:*

Fugiendi causa, *for the purpose of fleeing.*

It is used objectively:

Amor pugnandi, *love of fighting.*

Also it is used after some adjectives:

Avidus bellum gerendi, *eager to wage war.*

The *Accusative* is used with *ad* to express purpose:

Milites ad pugnandum misit, *he sent soldiers to fight.*

Non aptus est taurus ad equitandum, *a bull is not suited for riding.*

The *Dative* is used with adjectives implying *fitness,* &c.:

Locus pugnando idoneus, *a place suitable for fighting.*

The *Ablative* is used to denote *means, cause,* &c.:

Discit docendo, *he learns by teaching.*

Also with *a, de, ex, in:*

In vitia corrigendo summa est voluptas, *there is a great pleasure in correcting faults.*

De coenando deliberant, *they deliberate about dining.*

If the verb is transitive, it is more usual in Latin to use, instead of the gerund, the gerundive as an adjective agreeing with the object. It is important to remember that in this construction the object takes the case of the gerundive.

Thus, the example above might more idiomatically read: *In vitiis corrigendis summa est voluptas.*

The gerund and gerundive are frequently used impersonally:

Pugnandum est, *one must fight.*
Nobis eundum est, *we must go.*

Translate, giving every possible meaning of: Infandum, regina, jubes renovare dolorem. Dulce et decorum est pro patriā mori. Si monumentum requiris, circumspice. Tres cohortes adducit oppidi oppugnandi causā. Optissima est haec occasio ad leges mutandas. Non debuisti munera militibus dare. Juvat ire et Dorica castra visere. Meridie coenare solebat. Meridie coenavisse narratur. Ambitūs condemnari turpe putamus. Vires acquirit eundo. Brutus dicitur negavisse se pugionem ad Caesarem interficiendum paravisse. Sperabat puella se a reginā osculatum iri. I, sequere Italiam. Urbem ex suis faucibus ereptam esse luget. Quam celerrime pax nobis petenda est. Negavit hostibus parcendum esse. Non opus est Caesare maledicendo. Sciebam puellam servum amare. Negavit se unquam elephantum vidisse. Malo Romae manere. Dixi vos satis cibi habituros

Participles.—The participles are adjectives, and are normally used as such. The only idioms that call for note are:

1. The use of the past participle passive with a noun where English would use two nouns, one in the genitive depending on the other:

Caesar interfectus reipublicae exitium fuit, *the murder of Caesar* (lit. *Caesar slain*) *was the destruction of the commonwealth.*

2. The *Ablative Absolute* construction, noted under the heading Ablative.

Supine.—The form ending in *-um* is used with verbs implying motion to express *purpose:*

Cubitum ire, *to go to lie down.*

Fabros misit pontem exstructum, *he sent pioneers to build a bridge.*

The form ending in *-u* is used with adjectives to denote *that in respect of which* the adjective is applied.

Mirabile dictu, *wonderful to tell* (lit. *wonderful in the telling*).

Horribile visu, *dreadful to see.*

Note.—The form in *-u* never takes an object.

Translate, giving every possible meaning of: His rebus cognitis senatus Ciceronem jussit Catilinam punire. In silvas venatum abiit, quā re Tarquinio in horto ambulanti nuntiatā, milites jubet praesidio ei proficisci. Hoc vinum consule Planco factum est. Armis depositis ad castra revertērunt. Te dictatore res Romana florebit. Passis crinibus manus ad coelum tendunt.

The Verb in Compound Sentences.—By a compound sentence is meant a principal clause with one or several dependent clauses depending on it. In dependent clauses Latin employs what is known as the *Sequence of Tenses.* Roughly, by the sequence of tenses, where the principal verb is primary, it is followed by the present or perfect subjunctive; where it is secondary, the dependent verb is in the imperfect or pluperfect subjunctive.

The following table will make the system plain:

Scio qualis sit, *I know what he is like.*
Sciam qualis sit, *I shall know what he is like.*

Scivi qualis sit, *I have known what he is like.*
Sciero qualis sit, *I shall have known what he is like.*
Scio qualis fuerit, *I know what he was like.*
Scio qualis futurus sit, *I know what he will be like.*
Sciam qualis fuerit, *I shall know what he was like.*
Scivi qualis futurus sit, *I have known what he will be like,* &c.
Sciebam qualis esset, *I knew what he was like.*
Sciebam qualis futurus esset, *I knew what he would be like.*
Sciebam qualis fuisset, *I knew what he had been like.*
Scieram qualis esset, *I had known what he was like.*
Scieram qualis fuisset, *I had known what he had been like.*
Scieram qualis futurus esset, *I had known what he would be like.*
Scivi qualis esset, *I knew what he was like,* &c.

Note.—The historic present and the historic infinitive are treated generally as historic tenses and take a corresponding sequence.

The Subjunctive in Dependent Clauses. Cause.—In dependent clauses expressing the cause of the principal clause the subjunctive is used after *cum,* since:

Cum tyrannus interfectus sit, gaudeat populus, *since the tyrant is slain, let the people rejoice.*
Cum sit in nobis ratio, necesse est deum eam nobis dedisse, *since we have reason, God must needs have given it to us.*

After *quod, quoniam,* because, the subjunctive is used, except when the reason given is that supplied by the speaker or writer of the sentence:

Mirari Cato se aiebat, quod non rideret haruspex, *Cato used to say he wondered that the diviner did not laugh.*
Attico gratias agebat Cicero quod se vivere coegisset, *Cicero was grateful to Atticus for forcing him to go on living.*

But when Cicero writes this himself to Atticus, he uses the indicative after *quod:*

Gratias tibi ago quod me vivere coegisti, *I am grateful to you for forcing me to remain alive.*

Note.—*Quando, quia,* because, take the indicative.

Purpose.—Dependent clauses indicating *Purpose* go invariably into the subjunctive. Thus the subjunctive is used after *ut,* in order that; *ne,* lest, in order that—not; *quo,* in order that:

Haec scribo, non quo ipse legam, *I write this, not in order that I may read it myself.*
Haec res acta est ut nobiles restituerentur, *this thing was done that the nobles might be restored.*
Id egi ne interessem, *I did it so that I might not be present.*

Here is to be noted the idiom by which *ne* and *ut* are used after verbs expressing "fear":

Vereor ne quid Andria apportet mali, *I fear Andria will bring some evil* (lit. *I fear lest Andria may,* &c.).
Vereor ne exercitum habere non possit, *I fear he will not be able to have the army.*
Timeo *ut* tantos sustineas labores, *I fear you will not bear up under such great exertions.*

Some verbs are regularly constructed with a dependent clause of purpose introduced by *ut* or *ne.* Such are:

(*a*) Verbs meaning *to advise, persuade, request, command,* &c.:

Petunt atque orant ut sibi pareat, *they ask and entreat him to spare himself.*
Te hortor ut meas orationes legas, *I urge you to read my speeches.*
Ei persuadet ut ad hostes transeat, *he persuades him to go over to the enemy.*
Mihi ne abscedam imperat, *he orders me not to go away.*

Note.—*Hortor,* sometimes, and *jubeo,* command, regularly, take the infinitive.

(*b*) Verbs meaning to *try, endeavour,* &c.:

Nitebantur ne gravius in eum consuleretur, *they endeavoured to bring it about that the decision against him should not be too severe.*
Da operam ut valeas, *take care to keep well.*
Qui stadium currit, eniti et contendere debet ut vincat, *a runner in a race ought to endeavour and strive to win.*

Note.—*Conor,* try, always takes the infinitive.

(*c*) Verbs meaning to *allow, grant,* &c.:

Permisso ut seu dicere prius seu audire mallet, *it being allowed him to choose either to speak first or to listen.*

Note.—*Permittere* also takes the infinitive.

Non concedo ut sola sint, *I do not allow that they should stand alone.*
Neque suam consuetudinem pati ut socios desereret, *and (he said) that his habits of action did not allow him to desert his comrades.*

Note.— *Patior* takes the subjunctive only when it is coupled with *non* or *neque.*

(*d*) Verbs meaning to *decide, resolve,* &c.:

Plerique censebant ut noctu iter faceret, *many expressed the opinion that he should march by night.*

Placuit ei ut ad Ariovistum legatos mitteret, *it seemed good to him to send envoys to Ariovistus.*

Mihi cum Deiotaro convenit ut simul abiremus, *I agreed with Deiotarus that we should go away together.*

Note.—Some verbs with this meaning take the infinitive—e.g. *constituo*, resolve; but the subjunctive is, generally speaking, more regular.

The relative pronoun and relative adverbs are also used to introduce a clause of purpose in the subjunctive after verbs of motion :

Equitatum qui sustineret hostium impetum misit, *he sent a body of horse to sustain the enemy's charge* (lit. *who might sustain*).

Locum elegit unde castra videret, *he chose a place whence he might see the camp.*

In such a use ***qui* = *ut is*, *ubi* = *ut ibi*, *unde* = *ut inde***, &c.

Result.—Dependent clauses denoting *Result* are in the subjunctive. They are usually introduced by *ut*, so that, or its negative, *ut non :*

Non sum ita hebes ut istuc dicam, *I am not so dull as to say that.*

Non talis est figura ut eam factam a Scopa diceres, *the statue is not such that you would say it was made by Scopas.*

Casu accidit ut primus id nuntiaret, *it happened by chance that he was the first to announce it.*

Est mos hominum ut nolint eundem pluribus rebus excellere, *it is the custom of men that they do not wish one man to excel in too many things.*

Effecit ut honeste vivere non possem, *he brought it about that I could not live honourably.*

Note.—In clauses denoting *result* the strict sequence of tenses is often subordinated to the sense—*e.g.:*

Tam luxuriose degebat ut nunc pane egeat, *he used to live so extravagantly that to-day he lacks for bread.*

Under the head of *Result* may be classed the use of the subjunctive in dependent clauses introduced by the relative pronoun *qui, quae, quod,* to denote an attribute or characteristic; it is used in this sense especially after *dignus*, worthy, and its opposite *indignus;* after *demonstrative, indefinite,* and *interrogative pronouns;* after *nemo, nihil,* and *nullus;* after *comparatives* followed by *quam*, and after *sunt*, there are, and *est*, there is, used impersonally; *e.g.:*

Non videris dignus qui liber sis, *you do not seem worthy to be free.*

Is est cui facillime persuadeatur, *he is one who can be very easily persuaded.*

Quis est qui mortem non timeat? *who is there who does not fear death?*

Nil est quod oratori plus conveniat, *there is nothing more befitting an orator.*

Vigilantior est quam qui talibus insidiis capiatur, *he is too wide-awake to be caught in such a trap.*

Sunt qui discessum animi a corpore putent esse mortem, *there are some who think that death is the departure of the soul from the body.*

Sunt qui non habeant, est qui non curet habere, *there are some who have not, there is one who does not care to have.*

Subjunctive after Quin *and* Quominus.—*Quin*, but that, and *quominus*, lit., by which the less, are used with a dependent subjunctive after verbs implying *hindrance, falling short; quin* is also used after verbs expressing *hesitation.* In any construction *quin* is only used after a negative, expressed or implied in the meaning of the clause on which it depends; *e.g.:*

Facere non possum quin ad te mittam, *I cannot refrain from sending to you.*

Non est dubium quin plurimum possent, *there is no doubt that they were the most powerful.*

Non quin breviter reddi responsum potuerit, *not but that an answer could have been briefly given.*

Nemo erat quin hoc se audiisse diceret, *there was no one who did not say he had heard this.*

Nihil abest quin sim miserrimus, *there is nothing between me and abject misery.*

Hiemem credo prohibuisse quominus epistolas a te acceperimus, *I suppose the winter has prevented our receiving any letters from you.*

Translate, giving every possible meaning of :

1. Temporis tanta fuit exiguitas ut etiam ad galeas induendas tempus defuerit. 2. Ad App. Claudii senectutem accedit etiam ut caecus esset. 3. Nonnulli, pudore adducti, ut timoris suspicionem vitarent, remanebant. 4. Caesarem obsecrare coepit ne quid gravius in patrem statueret. 5. Lex lata est ne auspicia valērent. 6. Nostri ne quo loco erumperent, Pompeiani timebant. 7. Hoc unum vereor ne Senatus Pompeium dimittere nolit. 8. Cavete, judices, ne nova proscriptio instaurata esse videatur. 9. Dignus est qui imperet. 10. L. Pisonem ad Caesarem mittit, qui de his rebus eum doceat. 11. Neapolīs villam ēmit ubi placidā senectute frueretur. 12. Tam rapido gurgite Padus se praecipitabat ut Hannibal equites traducere non potuisset. 13. Orant ne rem in summum periculum deducat. 14. Decrevit Senatus ut Catilina hostis haberetur. 15. Paulum afuisse narratur quin urbs tota igne consumpta esset. 16. His persuaderi non poterat ut diutius morarentur. 17. Nolite dubitare quin huic uni omnia credatis. 18. Quid obstat quominus sit bea-

tus ? 19. Nemo est qui parricidium probet. 20. Cum ea ita sint, tamen pacem cum iis faciam. 21. Moriens, cum jam ceteris ex partibus oppressa mens esset, extremum sensum ad memoriam reipublicae reservabat. 22. Dicebant se timere ut res frumentaria satis commode supportari posset. 23. Non is sum qui amicos deseram. 24. Caesar vehementer irascebatur quod hostes Romanorum socios vexavissent. 25. Laborabat ut reliquas civitates adjungeret. 26. Eo erant vultu ut eos Argivos esse diceres. 27. Lamiam ad eum misi, qui demonstraret Caesarem sibi imperavisse ut ad me scriberet, ut in Italiam quam primum venirem.

Time in Dependent Clauses.—The general rule is that the dependent verb is in the indicative when its time is independent of the clause governing it, the subjunctive when its time depends on that of the principal clause. The conjunctions that introduce temporal clauses and their construction are as follows:

Cum, when, if it refers to the *present* or *future*, takes the indicative:

Cum hoc legeris, intelliges omnia, *when you have read this you will understand all.*

Cum aderis omnes dormibunt, *when you arrive all will be asleep.*

Cum canis omnes delectantur, *when you sing all are charmed.*

If it refers to the *past*, *cum* takes the indicative to denote a *point of time* and nothing more, the subjunctive to denote the *circumstances attending* the action of the main verb:

Dixerat hoc ille cum puer advenit, *he had said this when the boy came.*

Qui non propulsat injuriam a suis cum potest injuste facit, *he who does not, when he can, ward off an injury from those near to him, acts wrongfully.*

Aquilifer,cum ab hostibus premeretur, aquilam intra vallum projecit, *the standard-bearer, when he was being borne down by the enemy, threw the standard within the stockade.*

The difference in sense between the two moods is, it will be observed, not easy to define. Roughly, it may be laid down that the indicative is used:

(*a*) When *cum* means "whenever," and

(*b*) When by the use of *eo tempore*, *tum*, or some similar expression, it is made clear that *point of time* alone is meant to be expressed.

This rule can only be followed in writing Latin; it will be found on coming to read Latin authors that the boundary between the two uses is very narrow, and depends largely on the feeling of the writer.

Dum, *donec*, *quoad*, when they mean "until," and *ante . . . quam*, and *prius . . . quam*, meaning "before," take the indicative to denote *an actual event*, the subjunctive to denote *anticipation* in the mind of the subject of the main verb:

Sosiae non credebam donec fecit ut sibi crederem, *I did not believe Sosias till he made me.*

Hoc in aliud tempus differunt, dum ira defervescat, *they put this off to another time, until their anger cools.*

Ante aliquanto quam tu natus es, *some time before you were born.*

Priusquam quidquam conaretur, Balbum ad se vocari jussit, *he ordered Balbus to be summoned before him, before any attempt should be made.*

Dum, *donec*, *quoad*, meaning "while," "so long as," regularly take the indicative:

Ipse, quoad potuit, fortissime restitit, *as for himself, while he could, he made a stout resistance.*

Postquam, *ubi*, *quando*, &c., are generally used with the indicative.

Conditional Sentences.—A **Conditional Sentence** consists of two clauses, one containing the *condition*, and the other stating what follows as a result of the condition. The former is called the Protasis; the latter, which is the principal clause, is called the Apodosis. For example, in the sentence, "If you are well, I am happy," "If you are well" is the protasis, laying down the condition, while "I am happy" is the apodosis, which states as the principal fact what follows as a result of the condition being fulfilled.

There are three sorts of conditions:

1. *Vivid*, where the apodosis follows naturally if the condition is fulfilled, without anything being said to indicate whether it is fulfilled or not.

Type: "If so-and-so is the fact, then, &c."

A condition of this type may be past, present, or future, but, whatever the time, the indicative is used in both protasis and apodosis.

(*a*) *Present.*—Si vales, felix sum, *if you are well, I am happy.*

Nisi me amas, vita mihi vana est, *unless you love me, life to me is worthless.*

(*b*) *Past.*—Si hoc fecisti, bene egisti, *if you did this, you acted well.*

Post prandium foro ambulabat, nisi pluebat, *after lunch he used to walk in the forum, unless it rained.*

(*c*) *Future.*—Si me audietis, omnia tibi dicam, *if you will listen to me, I will tell you all.*

Nisi ante sextam horam veneris, actum erit de nobis, *unless you come* (lit. *shall have come*) *before the sixth hour, it will be all up with us.*

(*N.B.*—Note the idiom, *actum est de* with the ablative, "It is all over with . . .")

2. *Vague Future.*—Type: "If so-and-so were to happen, then . . . would . . ." In conditions of this type, the apodosis expresses what would happen if at any time the condition were to be fulfilled. The present or perfect subjunctive is used in both protasis and apodosis.

Abire nullo pacto possim si velim, *I could on no account go away, if I wished to.*
Si hoc audiat, irascetur, *if he were to hear this, he would be angry.*
Nisi omnem rem eis patefacias, decipiantur, *unless you made the whole thing clear to them, they would be deceived.*

3. *Unfulfilled Protasis.*—Type: "If so-and-so were true (but it is not), then, &c." In conditions of this type, the protasis expresses a condition that is, in fact, not fulfilled, and the apodosis states what would happen if it were. The time may be either past or present; in either case the subjunctive is used in both protasis and apodosis.

(*a*) *Present.*—The imperfect tense is used in both parts of the sentence.

Si Caesar adesset, urbs salva esset, *if Caesar were here* (*but he is not*) *the city would be safe.*
Nisi te noverim, mentiri dicerem, *if I did not know you* (*but I do*), *I would say you were lying.*

(*b*) *Past.*—The pluperfect tense is used in both parts.

Si Caesar adfuisset, urbs salva fuisset, *if Caesar had been here* (*but he was not*), *the city would have been safe.*

(*c*) *Mixed Time.*—Pluperfect in the protasis, imperfect in the apodosis.

Nisi deus voluisset, hodie non viveres, *if God had not willed it* (*but He did*), *you would not be alive to-day.*

Translate, giving every possible meaning of:
1. Vix flumen transierat cum dextrā tonuit. 2. Obsidio deinde per paucos dies magis quam oppugnatio erat, dum vulnus ducis curaretur. 3. Tityre, dum redeo, nostras pasce capellas. 4. Haud desinam donec hoc perfecero. 5. Dum haec in Apuliā gerebantur, Samnites urbem non tenuērunt. 6. Undecimo die postquam a te discesseram Capuam pervēni. 7. Hoc ego, prius quam loqui coepisti, sensi. 8. Oravit ut te ante videret quam e vitā discederet. 9. Si vis, dabo tibi testes. 10. Id persequar, si potero, subtilius. 11. De iis te, si qui me forte locus admonuerit, commonebo. 12. Ipsi auxilium duci ferre, si cupiant, non queant. 13. Haec descriptio, si esset ignota vobis, a me explicaretur. 14. Si aliter accidisset, Caesar non interfectus esset. 15. Tum magis id diceres si nuper in hortis Scipionis adfuisses. 16. Si valebis, cum recte navigari poterit, tum naviges. 17. Zenonem, cum Athenis essem, audiebam frequenter. 18. Socrates, cum inter amicos erat, de philosophiā eos interrogabat. 19. Nisi quid sceleste fecisset, capitis non damnatus esset.

Clauses of Comparison.—A clause of comparison is one which supposes a condition, not in fact true, to exist, to which the action of the main verb is compared. The mood is always the subjunctive:

Ceteri, tanquam ita necesse sit, sequuntur, *the rest follow, as though of necessity.*
Tantus eos metus cepit, velut si jam ad portas hostis esset, *as great a fear got hold of them as though the foe were already at the city gates.*

"*Though*" *Clauses.*—Clauses introduced by a word meaning "although" are in the subjunctive mood, except in the case of *quamquam*, which takes the indicative always, and *etsi*, *etiamsi*, *tametsi*, which take either mood.

In post-Augustan prose and in poetry the above rules are not closely adhered to.

Indirect Speech.—Indirect speech (*oratio obliqua*) is the narration of what someone thought or said, the thought or words narrated depending on a verb implying *saying, thinking*, &c. Thus, "I am going," is someone's actual words, *i.e.* direct speech (*oratio recta*); if I am reporting them to another person as having been spoken by myself or someone else, I can do so either by using inverted commas: He said, "I am going," or by using *oratio obliqua:* He said that he was going.

In English, indirect speech is expressed by the use of the conjunction "that" and the change of the time of the narrated verb to that of the verb on which it depends, as in the example given above. In Latin the rule is that in *oratio obliqua* the main clause adopts the accusative and infinitive construction, and dependent clauses go into the subjunctive mood.

Thus, *Te amo*, I love you, becomes in *oratio obliqua:* (*Dixit*) *se illum amare*, he said he loved him.

Hoc non faciam, I will not do this, becomes (*Negavit*) *se hoc facturum esse*, he said he would not do this.

Edo ut vivam, I eat to live, becomes (*Dixit*)

se edere ut viveret, he said he ate that he might live.

Note.—Note the sequence of tenses, *dixit* . . . *viveret*, following the regular rule.

Commands and questions in the second person go into the subjunctive in *oratio obliqua*. So, *I, sequere Italiam*, go, seek Italy, becomes (*Dixit*) *iret, sequeretur Italiam.*

Cur hoc facis? why do you do this? becomes (*Rogat*) *cur hoc faciat*, or (*Rogavit*) *cur hoc faceret*, the sequence of tenses being duly observed.

But when the question is in the 1st or 3rd person, the accusative and infinitive is used in *oratio obliqua*. Thus, *Num hoc feram?* shall I bear this? becomes (*Rogat*) *num se illud laturum esse.*

Conditional Clauses in Oratio Obliqua.—In *oratio obliqua* the protasis goes into the subjunctive, following the sequence of tenses, and the apodosis, which is the principal clause, takes the accusative and infinitive. The following examples will illustrate the working of the rule:

O.R. Si vales, bene est, *if you are well, it is good.*

O.O. Dixit, si valeret, bene esse.

O.R. Si me amabis, te amabo, *if you love me, I will love you.*

O.O. Dixit si ille se amaret, se illum amaturum esse.

O.R. Si hoc dixisti, mentitus es, *if you said this, you lied.*

O.O. Dixit eum, si illud dixisset, mentitum esse.

O.R. Si veneris, videbis, *if you have come, you will see.*

O.O. Dixit eum, si venisset, visurum esse.

O.R. Si hoc dicas, mentiaris, *if you were to say that, you would be lying.*

O.O. Dixit eum, si illud diceret, mentitum iri.

O.R. Si adesset, vinceret, *if he were here he would win.*

O.O. Dicit eum, si adesset, victurum esse.

O.R. Si eum vidissem, abiissem, *if I had seen him, I would have gone away.*

O.O. Dixit se, si eum vidisset, abiturum fuisse.

O.R. Si ibi venisses, interfectus esses, *if you had come there, you would have been killed.*

O.O. Dixit, si ibi venisset, futurum fuisse ut interficereris.

Note.—The form *futurum esse* or *fore* followed by *ut* with the imperfect subjunctive is always used in this type of condition in *oratio obliqua.*

The following extract from Livy shows how the transposition from *oratio recta* to *oratio obliqua* is effected in a running narrative:—

O.R.

Nullius consilium imperatoris in speciem audacius, re ipsa tutius, fuit quam meum. Ad certam victoriam vos duco: quippe ad quod bellum collega non ante profectus est quam ad suam satietatem peditum atque equitum datae a senatu copiae essent, eo vos, quantumcunque virium momentum addideritis, rem omnem inclinabitis: auditum modo in acie—nam ne ante audiatur operam dabo—alterum consulem et alterum exercitum advenisse, haud dubiam victoriam faciet.

O.R.

No general has had a plan of action seemingly more rash, but actually more safe, than mine. I am leading you to certain victory: surely in a campaign for which my colleague did not set out till forces of foot and horse had been granted by the senate to his full satisfaction, you, whatever additional weight of force you add, will turn the entire scale of events. Once it is heard during the fray (for I will take care that it be not heard before then) that the other consul and a second army have arrived, it will render the victory beyond all doubt.

O.O.

Negat ullius consilium imperatoris in speciem audacius, re ipsa tutius fuisse quam suum: ad certam eos se victoriam ducere: quippe ad quod bellum collega non ante, quam ad satietatem ipsius peditum atque equitum datae a senatu copiae fuissent, profectus sit, eo ipsos, quantumcunque virium momentum addiderint, rem omnem inclinaturos: auditum modo in acie—nam ne ante audiretur daturum operam—alterum consulem et alterum exercitum advenisse, [illegible] dubiam victoriam facturum esse.

Question and Answer.—1. A plain question in direct speech, when the speaker is in doubt as to the answer, is expressed by using the particle *-nĕ* after the emphatic word:

Meministine me in Senatu dicere? *do you remember my saying in the Senate?*

Or by using an interrogative pronoun:

Quis est ille miles? *who is that soldier?*
Quot sunt homines? *how many men are there?*

Or occasionally without using any special word:

Tu mihi etiam C. Gracchi mentionem facis? *do you indeed speak to me of Caius Gracchus?*

2. When the answer "yes" is expected by the questioner, *nonne* is used;

Nonne abiisti? *did you not go away?*
Nonne me amas? *don't you love me?*

3. When the answer "no" is expected by the questioner, *num* is used:

Num barbarorum Romulus rex fuit? *was Romulus king of a tribe of savages?* (*Of course not.*)

Num quis sapientiam odit? *does anyone hate wisdom?* (*Of course not.*)

Double questions—*e.g.* Is he here or at Rome?—are expressed in one of three ways:

1. By *utrum* in the first part, and *an* in the second:

Utrum me amat an te? *does he love me or you?*

2. By *-ne* in the first part, and *an* in the second:

Romamne veniam an hic maneam? *am I to come to Rome or remain here?*

3. By *an* in the second part.

Eloquar an sileam? *am I to speak or be silent?*

When the second part in English consists of the words "or not," *e.g.* "Is he here, or not?" *annon* is used, or (rarely) *necne*.

Dicam huic annon? *shall I tell this man or not?*

History of Roman Literature

The first form taken among any people by the manifestation of the literary spirit is the composition of verses. A set composition, intended to be remembered, before the general use of writing was put into the form best adapted for retention by the memory, and that form necessarily adopts the shape of some metrical arrangement. To this general rule the Romans were no exception. Before 240 B.C. we have extant nothing that can be said to be a literary composition, but we know that on occasions of public holiday the people indulged in some sort of organised clowning, which consisted chiefly of one or two performers dancing and bandying broad jokes with one another and with the audience. These humorous dialogues, known as *Saturae*, akin very much to the "back-chat" of the modern American music-hall artist, were set in the metre indigenous to the Latin tribes, the Saturnian metre, one of rapid movement and full of life, approximating very nearly to the cadence of the ordinary spoken language. At the same time, the populace interchanged with one another scurrilous jests in a similar metre, the *Fescennine* verses, which in later days were the type of unrefined abuse.

The service of religion also required set forms, which again found expression in Saturnian verses. Scarcely any remains exist of this primitive literature, religious or secular, and it is very unlikely that much of it, and almost certain that none of the secular verse, was committed to writing.

The success of Rome in the first Punic War, and the accession in wealth and importance that was its result, had a great uplifting effect on the character of Roman social life. More especially, the contact with the advanced civilisation of the Greek cities of Southern Italy introduced at Rome a sudden advance in culture and appreciation of the arts hitherto unknown. Greek slaves were brought to Rome, who taught their masters the arts in which they were proficient, and made known to them the treasures of Greek literature.

Among these was one Andronicus, whose servitude was in the great house of Livius. He dwelt among them for thirty years, during which the Greek leaven continued to work at Rome. At last, in 240 B.C., under the patronage of his master's family, Livius Andronicus produced a Satura unlike all that had preceded it, in that it possessed a plot. In fact it was a drama, either translated or adapted from a Greek original. From this time onward, drama proper flourished at Rome, the more so as the taste for Greek culture continued to grow every year.

Livius Andronicus also composed a Latin translation of the *Odyssey*. This work possessed little literary merit, but it opened up a new field of interest to the citizen of Rome, besides indicating a higher level to which literature might attain, and turning Roman letters into the channel which they were eventually to follow.

The example of Livius Andronicus was followed shortly after by **Cn. Naevius,** whose work is significant by reason of his being a true-born Roman. His literary activity consisted in adapting Greek plays, especially the works of the comedians. Naevius followed the example of the Old Attic Comedy, in making his plays centre round some political question, and in utilising the traditional scurrility of the old Saturae for pillorying those who were prominently before the public. During the banishment which his outspokenness brought upon him, Naevius composed an epic poem on the first Punic War, in which he put together for the first time the traditions about Aeneas, the mythical progenitor of the Roman people, into a connected story. The account of the flight from Troy, and the wanderings of the Trojan hero and his followers, were detailed with an abundance of episode, to which the great singer of Aeneas, Vergil himself, was largely indebted for the incidents of the *Aeneid*. The work, as far as can be judged from the fragments that survive, was merely a bare narrative in metre, lacking any pretence to poetic adornment.

Plautus.—The route which Naevius had pointed out for comedy was followed by Plautus, his younger contemporary. Beginning to write shortly before 200 B.C., Plautus produced comedy after comedy, right up to his death in 184 B.C. Taking warning by the fate of Naevius, he confined his plays to the model of the late Greek comedians, leaving politics alone, and dealing entirely with scenes of private life. Into the frame of the Greek plots which he adapted, Plautus worked the language of Roman everyday life, and perhaps we have no surer guide to the Latin that was used in familiar conversation by the common people. Avowedly he wrote only to amuse, and the humorous situations conceived by the comedians of Greek decadence

appealed strongly to the lively and rather coarse vitality and the keen passions of the Italian temperament. Generally speaking, his stage-types were conventional; his young men and their mistresses, his money-lenders and parasites were those of Alexandria, though here and there he dealt a shrewd hit at the weaknesses of his audience, and such a character as the *Miles Gloriosus* shows that when he cared to exercise it he possessed considerable power of character delineation.

The successor of Naevius in epic poetry was **Q. Ennius,** 239–169 B.C. Born among the Greek cities of Southern Italy and educated there, he served in the Roman army until he came to Rome in 204 B.C. At Rome he enjoyed the intimacy of the noblest families, and was the particular friend of the Scipio who conquered Hannibal. The combination of his early training and his later Roman environment enabled him, for the first time, to effect a true reconciliation between the Greek and the Roman genius, and made of the product a homogeneous native literature. His tragedies gave a new life to that form of drama; his works, though inspired by the Greek masterpieces, were neither translations nor adaptations, and under his care there grew up an essentially Roman tragedy. The characters were conventional in so far as they were Greek, but the sentiments they expressed were Roman, and the whole spirit of his tragic works was that of the people for whom they were written.

In the *Annals*, the chief work of his life, Ennius gave the history of Rome. The work, which only survives in fragments, dealt with the inspired destiny of the Roman people as made clear by the various incidents through which their history had passed. With some of the art of the great Greek epics, Ennius put into language the national traditions of Rome and the ideal characteristics of the national character. The men whose story he told all illustrated the virtues and aims of the best type of Roman, by their devotion to the State and their earnest working for its advancement.

In the *Saturae*, Ennius gave an old name to a new form of composition. Instead of the old scenic element which had now been usurped by comedy, his Saturae consisted of his thoughts on subjects of the day, expressed in a familiar and effective manner, and often rambling on from one topic to another. He thus forms a link between the old Saturae and the satires of Lucilius and Horace.

Cato.—While Ennius was building up the structure of Latin heroic verse, and Plautus was pouring into Roman vessels the old wine of Greek comedy, one man of outstanding gifts refused to join in the Graecising tendency of those around him. Marcus Porcius Cato used all the weight of his influence and his intellect to stem the Greek tide that he feared would submerge the identity of his countrymen, and while others were forcing the Latin language into channels that were not natural to it, gave it an impulse which enabled it to develop along lines of its own. Cato's speeches have not survived, save in fragments, but these show that he had great command of language. At a later time, when literary criticism had become an art, there were some who thought him a greater orator than Cicero, who himself pays Cato the tribute of being witty and concise.

De Re Rustica is a treatise on husbandry, one of a series on various subjects. It is written in a series of hints to the farmer, with no sort of literary adornment, but shrewd and to the point, and is of interest as showing in its simplest form the prose which was to develop into the magnificent instrument of Cicero.

Terence.—The tendency against which Cato fought is most clearly illustrated by the comedies of Terence, who came to Rome soon after the fall of Carthage. In the six plays which were all his short life allowed him to produce, he shows how slavish admiration for another language may imperil the literature of one's own. Terence has many of the virtues of an accomplished writer; his style is smooth, his language polished, and his drawing of character is careful and exact, but the inspiration is stifled. Whereas Ennius and Plautus used the forms of Greek as a vehicle for thoughts of their own, Terence merely imitates, under the fatal illusion that by reproducing the very tones of another language he was making the most perfect use of his own. The result was mediocrity, a polished style being discounted by the lifelessness of his thought.

After Terence Roman comedy sank very low, and the type of mind to which comedy gives expression sought outlet in the form of Satura introduced by Ennius. The Satires of **Lucilius** (160–102 B.C.) definitely settled the form which familiar poetry was henceforth to take. Little is left to us of his work, but we know that a later age regarded him as the originator of that blending of prose style with metrical form which reached its height in the Satires and Epistles of Horace. The Satires of **Lucilius** consisted of criticisms of men, books, and manners, enlivened by vivid pictures of contemporary life, in a style plain enough to appeal to the man in the street, and attracting the man of culture by its delicacy and genius.

Lucilius closed the list of the great names of the early period of Roman literature. The stormy days that ended the second century and ushered in the first were not conducive to a flourishing literature. Considerable activity did, in fact, exist: we know that **Accius** wrote successful tragedies, and **Afranius** was prominent as a writer of comedies, but it was prose that showed most life during this period. In

the realm of oratory. **Scipio** the younger, the **Gracchi,** and others were masters of what was becoming a science, and their excellence is reflected by the mastery of Cicero, who was their direct successor. At the same time, men were writing on history and antiquities, and though time hides their work from us, some fruit of their labours survives in the works of Livy and Varro, whose authorities they often were.

Thus ends the early period, one in which Latin literature found itself. Drawing inspiration and form at first from Greek, and then gradually, as confidence and strength were gained together, relying more and more on native genius and native forms of expression, the early writers prepared a way along which the masters of the golden age might pass in triumph.

The Age of Cicero.—With the death of Sulla at the beginning of the second quarter of the first century B.C. there started the second period of Roman literature, the age of Cicero. The Social War, ending as it did in the extension over all Italy of Roman citizenship, added a great impulse to literature, both by the broadened outlook that all men gained therefrom, and by the admission to the franchise of intellect of the agile Italian imagination. There arose for the first time a real reading public, one which enjoyed good literature and constantly demanded fresh supplies. The result was a quickening of the literary spirit; appreciation is the surest spur to production, and men were quickly forthcoming to supply the public demand.

In the realm of prose **Cicero** ranks first. His writings fall into three classes—speeches, letters, and philosophical works. It is by his oratory that he is most famous; the traditions handed down from the time of the Gracchi are caught up by him and carried to their utmost height. His speeches show the Latin language at its best as a vehicle for expressing convictions or conveying emotion. With a command of language that none have surpassed, he combined every art of the trained orator, sure of his knowledge of men and the effect that words can have upon them. To this is added a feeling for form and rhythm so true that the reading of his best speeches aloud gives almost the impression of verse.

The letters of Cicero are in a more familiar strain. Covering every variety of subject of personal interest, they are written in a natural style, more easy than that of the speeches. As a guide to the family and political life and methods of thought of his time, they are invaluable.

As a philosopher Cicero added nothing to the world's store. His rôle is rather that of the expositor than of the creative genius, and he is content with restating the doctrines he has learned in language so simple, and in a style so pure, that all who run may read. The moralising of the *De Senectute* may not inspire, but such as it is, it is expressed in a manner both lucid and interesting.

Julius Caesar is a writer of another stamp. His histories of the Gallic War and the Civil War are masterpieces of narrative writing. Simple in style and without a superfluous word, they give a plain account of actual events, devoid of all personal feeling. The simple directness of his literary style perhaps gives us as true an impression of Caesar as any other record of him that we possess.

Historical writing of this period is also represented by **Sallust,** who occupied his retirement after Caesar's death by writing the *Historiae,* a record of the years immediately following the death of Sulla, and monographs on *Catiline* and *Jugurtha.* His style is modelled on that of Thucydides, and forecasts the change in prose that was to be apparent under the Empire in its use of Greek idioms and constructions.

Cornelius Nepos also contributed to the writing of history by his series of biographies. Purer in style than Sallust, and without any attempt at rhetorical adornment, his work has little literary merit, and is chiefly of value as a record of facts and as an easy book for the reading of beginners.

Among the many writers on miscellaneous subjects, one survives, the antiquarian **Varro,** who wrote on antiquities, biography, grammar, and agriculture. Varro is a voluminous writer, but of a dulness that is hardly compensated by the usefulness of the information that he collected.

Lucretius.—This period saw the awakening into life of Latin Poetry. The straining of Ennius with a new material, and the tentative experiments of his successors, at last gave way to genius sure of itself and master of its craft, and Poetry came into her own. Lucretius (99–55 B.C.) was the first to break forth from the chrysalis in his hexameter poem *De Natura.* Inspired by the doctrines of the school of Epicurus at their highest, he gave to the world a poem remarkable for its insight into natural causes, and the scientific intuition of its speculations, while grandeur of rhythm and high poetic imagination give it a high place in the range of the world's poetry. Untouched by the tide of Greek influence that was always threatening to swamp Latin poetry, his Latin is pure in a time when Latin was most perfect, and, combined with the stateliest metre ever devised by man, affects the mind in its most perfect parts as does some deep-stopped organ. In places, where science and poetry conflict, poetry has to give way, but the poem never becomes mean, and its stately progress swells here and there into the highest expression of true reverence and lofty poetic feeling.

A perfect counterfoil to Lucretius was the group of which Catullus (87–54 B.C.) alone

survives to us. **Cinna and Calvus** we know only by their reputation, but, if they were on the same plane as he, then their loss is a heavy one. **Catullus** was a professed follower of the Alexandrian school, steeped in the Greek polish that was part of the equipment of young men of his class. His experiments in various styles and with various metres show this, as well as his intimate use of Greek mythology. Yet throughout his work there is such delicate feeling, such passion, and such poetic power in the simplicity of his language, that he stands out as one of the greatest lyric poets of the world.

The Augustan Age.—With the Republic ended the second period of Roman literature, one marked by an advance in technique from the founders of Latin literature, and by a vigour of thought, independence of character, and strength of passion to which succeeding generations subservient to an Emperor could not attain.

The Emperor Augustus brought Rome to the zenith of its order and magnificence, and after the troubled times that marked the end of the Republic, men were glad to settle down under a wise rule. The result, however, was a loss of national energy; relief from anxiety brought with it relief from State cares altogether, and the inevitable consequence was loss of interest in public affairs. The literature of the Augustan age reflects this tendency, and side by side with the culmination of literary excellence shows an acquiescence in the loss of individual responsibility and a leaning towards paths that are easy, which inevitably led to loss of inspiration.

The decay of independent political feeling brought in its train an increasing attention to the interests of private life, and Greek art came more and more to assert its sway over Roman thought and letters. At the same time, literature began to be a profession to which men might devote all their energies; to this and to the existence of a Court where influence could make or mar, was due the institution of literary patronage. Such men as Maecenas, the patron of Vergil and Horace, cultured and influential, gathered round themselves a circle of followers of art, whom they assisted to gain favour, and who in return took care that their patron's fame should not diminish.

Three men—Vergil, Horace, and Livy—arose to perpetuate the relief felt under the new régime and the pride that a Roman took in the exaltation of his city.

The greatest of these was **P. Vergilius Maro** (70 B.C.–A.D. 19). Vergil's first work was the *Eclogues*, published in 38 B.C.. Admittedly imitations of Theocritus, they are often uncertain and flat in execution. The *Georgics*, published some seven years later, are the work of the poet's first perfection. Completely at home with his subject, the various aspects of husbandry, Vergil brought to play on it his full poetical powers and a complete mastery of technique, producing as the result a perfect example of its type.

The poem, however, by which Vergil lives for the ordinary man is the *Aeneid*, an epic poem in twelve books, relating the story of Aeneas' escape from Troy and his wanderings until he planted foot on Roman soil. In all probability the scheme of the *Aeneid* was approved, if not directed, by the Emperor; certainly it achieves its object, which is to glorify the tradition and destiny of Rome and of the Empire, and by stirring up patriotism among the people to lift them to a plane of feeling where they might accept and combine with the Imperial system for the aggrandisement of the State. Incidentally the *Aeneid* shows the Latin hexameter at perfection—thought, language, and metre being at the same time majestic and yet tender, powerful and yet smooth.

Vergil added indirectly to the store of Roman poetry by introducing to his patron, Maecenas, the writer whom we know as Horace (65 B.C.–A.D. 8). Horace's first work, the *Epodes*, was copied from Alexandrine models, being epigrammatic exercises in personality. Next came the *Satires*, less epigrammatic but more purely Roman in form and spirit, which are sketches of the life and manners of the day. The *Odes* are finished poems in lyric form, marked by perfect command over metre and language, and rich in shrewd observation. The work of his prime, the *Epistles*, are similar to the *Satires*, but more elegant and polished, and abounding in terse observations on manners and society.

Horace was a man of the world, but he was a poet as well, and the result has been to make him the most loved of ancient writers; no poet in all ancient literature has furnished more pointed and more elegant quotations to writers and speakers of modern times.

It was in this period that elegiacs first became fashionable. Catullus had experimented with them, but they were not the form in which his genius could be best expressed. Now, however, a school of elegiac poets arose, remarkable rather for elegance than for loftiness of inspiration.

Tibullus, Propertius, and Ovid have survived to represent this school. Of these, **Tibullus** is graceful and refined, singing of simple things in a lifeless manner, and never rising above the dead level of gentlemanly mediocrity. **Propertius** is more robust. His style is less elegant than that of Tibullus, but he has the power of showing feeling and an eye for dramatic situation, and so can command the sympathies of the reader.

Ovid (43 B.C.–A.D. 18) is a poet of unbounded facility. All his work shows complete mastery of the medium with which he worked, and especially in his adaptation of the heroic

hexameter to the lighter and more fanciful subjects of his *Metamorphoses*, a collection of mythological stories. His *Fasti*, a poetical calendar, shows much of the pride in Roman history that Augustus endeavoured to stimulate. His love poetry is bright and perfect in style, but shallow in feeling, and often very gross. The works which closed his career, the *Tristia* and *Ex Ponto*, are lamentations in exile, full of genuine feeling, but lacking in dignity.

In the realm of prose **Livy** (59 B.C.–A.D. 19) performed the same function as Vergil in popularising a feeling of patriotism and magnifying the Empire. His history of Rome from the beginning down to 9 B.C. is written in a bright and picturesque style, sometimes compared to that of Macaulay. His Latin shows the beginning of the tendency to use poetical diction in prose. Keen to dwell on the glory of Rome, he did not trouble overmuch to investigate facts or to take any pains in verification, so that his work is of less value as a history than it might have been had not knowledge been eked out by imagination.

These names close the Augustan age, the chief features of which may be thus summed up. It shows the creative genius of Roman literature at its fullest power, combined with the elegance and polish of masters of the language. But that very polish marked the beginning of the decline, and henceforward skill in technicalities is developed at the expense of true inspiration.

The era of the Silver Age of Latin literature was led up to by the writings of the early post-Augustans. Of those that survive, the poem on Astronomy of **Manilius** shows the highest level of language and of inspiration. The *Fables* of **Phaedrus,** the Histories of **Velleius Paterculus** and **Valerius Maximus,** and the work on Architecture of **Vitruvius,** illustrate the increasing loss of inspiration and the debasing of the language, due to the growing cosmopolitan character of the population of Italy.

The Silver Age proper began in the reign of Nero. Its salient feature is the increasing penetration of the Stoic philosophy into the life of Rome. The earliest and greatest exponent of Stoicism is **Seneca,** whose inferiority as a writer is compensated by his value as a teacher of morals. His philosophical writings, though marred by the passion for rhetoric of his time, combine high thinking with sincerity of feeling. His tragedies are lifeless exercises in rhetoric, correct and sometimes grand in form, but devoid of the dramatic sense and poor in characterisation.

Seneca's nephew, **Lucan,** is the sole outstanding poet of this period. The *Pharsalia*, his only extant work, is an epic on the struggle between Caesar and Pompey, who is its hero. Its lofty style and often trenchant phrases are spoilt by the straining of thought and expression of the rhetorician, which combine with a tedious rhythm to justify Quintilian's criticism that he is *magis oratoribus quam poetis imitandus.*

Lucan's contemporary, **Persius,** wrote Satires on the model of Horace. He is not a man of the world, however, but a bookman, and the result is to make his style involved and his thought obscure.

One other writer of Nero's reign stands out. **Petronius** wrote a novel describing the adventures of a freed slave, which gives us a perfect idea of the Latin of the common people. It is remarkable for its humour and its vivid descriptions of life and manners among different classes.

After the quiet days at the beginning of Nero's reign literature stood still until the time of Domitian. Under him **Statius** (45–96) wrote verses, which were the admiration of his time. That admiration is a sufficient index of the literary degeneracy of the time; for, judged from a modern standpoint, his work is over-elaborated and wanting in inspiration. The *Silvae*, a collection of short pieces on familiar subjects, are polished and graceful, but their artificiality makes them of little value as expressions of thought or feeling. The *Thebaid*, an epic on the war of Thebes, is clever and tasteful, but is eloquent of the skill of the author rather than of his genius.

The *Argonautica* of **Valerius Flaccus** is an inferior work, prolix and rhetorical, and entirely without imagination.

Silius Italicus also wrote an epic on the Punic War. It is enough to say that it contains all the traditional apparatus of Homer and Vergil as dry bones with no originality or inventive power to make them live.

The *Epigrams* of **Martial** form the largest collection of this class of writing that is left to us. Martial gives a clear picture of contemporary life; he had not the moral indignation of Juvenal to make him exaggerate. He wrote to make a living, and consequently his main object is to amuse. He lacks the delicate touch of Horace or Catullus, whom he strove to emulate, and so illustrates the poorer side of Roman taste—its love of verbal cleverness and its tendency towards heavy coarseness.

The *Natural History* of the **Elder Pliny** is a painstaking and accurate work, written in a plain and somewhat dull style.

The outstanding feature of this generation is the treatise of **Quintilian,** entitled *Institutio Oratoria.* By it he stands eminent as a rhetorician and writer, and also as a literary and artistic critic of very great merit. The most valuable portions of his work are those in which he gives a critical sketch of the whole of Latin literature, and again where he lays down the discipline to which the would-be orator must subject his nature.

In the next generation, which closes the roll of classical Latin, only three names stand out.

Tacitus (64–119) wrote a life of Agricola, a study of the German tribes, and two works, the *Annals* and the *Histories*, giving the history of Rome from the death of Augustus. Tacitus is a writer of great dramatic force and had at his command a power of epigram which makes his work unique in literature. His satiric sense, as with Juvenal, tends to distort the picture, but the result is full of interest, and justifies his title of the Roman Gibbon. His Latin is steeped in Vergilian phraseology, and abounds in Greek constructions; his natural terseness leads to syncopated idioms of his own, which makes it not easy to read him, and difficult to render him in English as concise as his own Latin.

The *Satires* of **Juvenal** are the last of their type. They give us wonderfully vivid pictures of the life of the time, exaggerated by the fierce indignation with which its vices inspired him. His power over language is very great; few ancient writers have lived to a larger extent in familiar quotations.

Juvenal's contemporary, **Pliny the Younger**, has left us a series of letters, which give a clear picture of a pleasant, cultured, ordinary man of taste. Pretending to no inspiration, they throw light on the life of his time, and especially illustrate the agreeable "pottering-about," which was the only occupation for the leisure of a well-to-do Roman of refinement.

With Pliny closes the history of classical Roman literature. Minor writers continued to produce works of little literary value, such as **Suetonius'** *Lives of the Caesars*, published under Hadrian, a mere string of anecdotes and personal descriptions, devoid of style, and written with no historical perception. The centre of European culture shifted to Athens, where a Graeco-Roman literature sprang up, with which we are not concerned.

How to Read Latin

A fact that is too often forgotten by teachers of languages is that, when spoken and heard by those whose native tongues they are, each word, as it is spoken, is grasped and appreciated immediately; that, if it is capable of more than one construction or meaning, the mind of the hearer holds it automatically in suspense without interrupting the flow of the sentence, until the remaining word or words are heard which classify it finally.

For instance, when a speaker says, "I know the *man's* honest," *man's* is immediately recorded by the hearer as being either equivalent to *man is* (*e.g.* "The man is right"), or to the genitive (*e.g.* "I know the man's wife"). The choice between these two possibilities depends on what follows, and the mind of the hearer therefore reserves its decision until it hears the word *honest*. Here, again, *honest* may be predicative after the verb *is*, or may describe some noun to follow which depends on the genitive *man's*. All doubt is finally disposed of by the stop after *honest*, which rules out the second of these two possibilities.

This process, of course, is as rapid as that of speaking itself, but it does in fact take place, and in reading also the same course is pursued, the eye taking the place of the ear. This fact has generally been lost sight of by teachers of Latin, with the result that the student has had to go hunting about from end to end of a sentence in order to pick out first the verb, then the subject, then the predicate, and so on. The consequence has been to increase the likelihood of going wrong and to lose all touch with the natural Latin order of words, which has to be learned all over again when the student has acquired sufficient proficiency in putting together the dissected puzzle set him by a misguided system.

Assuming that the preceding articles on grammar and syntax have been carefully studied, and that the exercises have been translated with special pains to find out *every possible meaning* that the sentences may contain, the following exercises will prepare the way for rapid and intelligent sight-reading of the Latin authors. The system of notes therein adopted is that propounded by Professor Hale of Cornell University.

First Exercise (Livy, xxi, 47, 1)

Hoc [1] primum [2] cum [3] Hannibalo [4] proelium [5] fuit [6, 7]; quo [8] facile [9] apparuit [10, 11] equitatu [12] meliorem [13] Poenum [14] esse [15] et [16, 17] ob [18] id [19] campos patentes,[20, 21] quales sunt inter Padum Alpesque, bello gerendo [22] Romanis [23] aptos [24] non esse.[25]

[1] May be one of three things. What are they? Abl. sing. masc. or neut., or nom. or acc. sing. neut.

[2] May be an adverb, or acc. sing. masc., or nom. acc. sing. neut. of an adjective.

[3] May be a conjunction or a preposition. In the former case it will command a dependent verb, in the latter it will take the ablative case.

[4] What case is *Hannibale*? The ablative. What inference follows? That it depends on *cum*, which is therefore a preposition.

[5] May be either nom. or acc. sing. It is neuter. What inference follows? That *Hoc* and *primum* agree with it.

[6] Can the verb *to be* govern an accusative? No. Hence *Hoc*, *primum*, *proelium* must be nominative. Of these part must be subject, part predicate. *Hoc* must be subject, being emphasized by coming first in the sentence.

[7] What is shown by the stop after *fuit*? That there is no dependent clause, therefore *cum* is undoubtedly a preposition.

[8] What part of speech? Conjunction or relative pronoun.

If the former, it requires a subjunctive dependent verb. If the latter, it refers either to the whole preceding sentence or to a noun therein.

[9] May be either of what parts of speech? Adjective in nom. or acc. neut. sing., or adverb.

[10] May be impersonal, or governed by a subject yet to come.

If impersonal, what construction will follow? The accusative and infinitive.

[11] What inference now follows as to *facile*? It is an adverb qualifying *apparuit*.

[12] What part of speech? Ablative of supine.

What meaning will it then have? Either *means* with a verb, or ablative of the thing in respect to which with an adjective.

[13] What part of speech? Adjective.

Hence *equitatu* is abl. of respect depending on it.

[14] Obviously acc. sing. masc. agreeing with *meliorem*.

[15] Must depend on *apparuit*. With the preceding acc. it forms the acc. and infin. construction after *apparuit*, which is thus impersonal.

[16] What three uses has *et*?

1. Connecting two words = *and*;
2. As the first of two *ets* = *both . . . and*;
3. As bearing on a single word = *also, even*.

[17] What uses may *et* have, in each case, in the present passage? It may connect *apparuit* or *meliorem* to something that follows; or it may be the first of two balanced *ets*; or it may emphasize a word or phrase to follow.

[18] What case does *ob* take? Accusative.

Of the three accusatives that follow, which is the most likely to depend on it? The nearest.

[19] What part of speech? Neuter nom. or acc. of pronoun *is*. Obviously acc. depending on *ob*.

[20] What part of speech? Nom. or acc. plur. masc. or fem. of pres. part. of *pateo*. Obviously agrees with *campos*.

[21] What is the construction of *campos patentes*? Must be another acc. and infin. after *apparuit*, connected with the former acc. and infin. by *et*.

[22] What is the construction of *gerendo*? Dat. or abl. sing. agreeing with *bello*. If dative, depends on some word to follow. The gerund takes the dative of the person by whom the act is to be done.

[23] May be dat. or abl. plural. Must be dative, depending on the preceding gerundive.

[24] What is the construction of *aptos*? It takes the dative of the thing for which a person or thing is fitted. It goes, therefore, with *bello gerendo*. It must agree with *campos*.

[25] Completes the second acc. and infin. construction; *campos patentes*, coming first, must be its subject, and *aptos* its predicate.

The passage thus runs literally:

"This was the first battle with Hannibal, by which it was easily apparent that the Carthaginian was better in horsemanship, and on account of this that open plains, such as there are between the Po and the Alps, were not suited to carrying on war by the Romans."

Having thus got the sense of the passage we can proceed to put it into idiomatic English:

"This was the first engagement with Hannibal; from it clearly appeared that the Carthaginians were superior in cavalry, and that on this account open plains, such as those between the Po and the Alps, were unsuited to the Roman arms."

Now, having exchanged the Latin for the English idiom, read the passage once more *aloud* in Latin, endeavouring to express the meaning by voice inflexion, as one would do in English.

This process should be gone through with each sentence. The student should write down every possible meaning of each word in its order, taking care not to look at one word before he has completely dealt with the last. Words of doubtful meaning or construction should be left in abeyance until the word is reached which gives the key. On reaching the end of the sentence the meaning will be clear; go back and translate the whole, reading it rapidly in English, as idiomatic and free as you like; then read it over again aloud and rapidly in Latin, and go on to the next.

This method, if faithfully pursued, and by its faithful pursuit alone can success be attained, will enable the student, in a surprisingly short time, to dispense with the elaborate system of notes; he will be able to read the Latin straight on, merely pausing to make notes when a word or phrase new to him presenting some special difficulty is encountered. And in the end he will find that he can read sentence after sentence in Latin without stopping to translate, performing at the same time the double function of reading the Latin and sensing its meaning in English. This will lead him to the stage at which he can think in Latin, when nothing will stand between him and the full enjoyment of what he reads.

The following exercises will serve as models, and should be carefully studied.

SECOND EXERCISE (Cicero, *De Senectute*, 55)

Possum [1] persequi [2, 3] permulta [4] oblectamenta [5] rerum [6] rusticarum,[7] sed ea [8] ipsa [9] quae [10] dixi [11] sentio [12] fuisse [13] longiora.[14, 15]

[1] What construction follows *possum*? The infinitive.

[2] What part of speech is *persequi*? Pres. infin. of *persequor*. It therefore probably goes with *possum*.

[3] Is it transitive or intransitive? Transitive, therefore an acc. is to be expected.

[4] What part of speech ? An adjective in the nom. or acc. neut. plur. May mean "many things," or may agree with some noun which follows.

[5] Either nom. or acc. plur. Is qualified by *permulta*. Must be the object of *persequi*.

[6] Genitive plural. Depending on what ? On *oblectamenta*. What gender ? Feminine.

[7] What part of speech ? Adjective in gen. plur. fem. Must qualify *rerum*.

[8] What part of speech ? May be nom. sing. fem., or nom. or acc. neut. plur. of *is*.

[9] May be nom. sing. fem., or nom. or acc. neut. plur. Probably agrees with *ea*.

[10] May be nom. sing. fem., or nom. or acc. neut. plur. either of relative or interrogative pronoun. As it follows so closely on *ea ipsa*, with which it seems to agree, is probably the relative pronoun.

[11] First pers. sing. perf. indic. Transitive verb governing the acc. Obviously its object is *quae*. If *quae* is its object, then *quae* must be neut. plur., and so must *ea ipsa*.

[12] What do you expect after *sentio* ? Either an acc., or acc. and infin.

As it is in the 1st person, what inference follows as to *ea ipsa* ? That *ea ipsa* is acc. and governed by *sentio*.

[13] Perfect infinitive. Together with *ea ipsa*, therefore, forms the acc. and infin. construction depending on *sentio*.

[14] What must it agree with ? *ea ipsa*.

[15] What may it mean ? "Longer," or "Too long."

Which does the sense require ? The latter.

Translation : "I could go on to tell of very many pleasures afforded by rural pursuits, but I feel that what I have already said has been too long."

The remaining exercises are intended to be noted by the student himself.

THIRD EXERCISE (*Livy*, xxvii, 48, 4)

Hasdrubal, omissa munitione castrorum, postquam pugnandum vidit, in prima acie ante signa elephantos collocat.

"Hasdrubal, having failed to fortify his camp, when he saw that he must fight, stationed his elephants in the front of his line of battle, just before the standards."

FOURTH EXERCISE (Cicero, *Pro Archia*, 28)

Nulla enim virtus aliam mercedem laborum periculorumque desiderat praeter hanc laudis et gloriae : qua, quidem, detracta, quid est quod in hoc tam exiguo vitae curriculo tantis nos in laboribus exerceamus ?

"For no virtue desires any reward for the toils and dangers it undergoes other than this one prize, praise and fame ; and when that too is taken away, what is there in this short span of life to induce us to wear ourselves with such great exertions ?"

FIFTH EXERCISE (*Livy*, xxvii, 8, 9)

Consules, priusquam in provincia irent,[1] duas urbanas legiones, quantum opus erat [2] ceteris exercitibus militum, scripserunt.

"Before going to their spheres of action, the consuls enrolled two city legions to the number of men required by the other divisions."

[1] What is the force of the subjunctive after *postquam* ?

[2] What is the construction of *opus est* ?

SIXTH EXERCISE (Cicero, *De Senectute*, 66)

Quarta restat causa, quae maxime angere atque sollicitam habere nostram aetatem videtur, appropinquatio mortis, quae certe a senectute non potest esse longe.

"There remains a fourth cause which seems to pain and keep in trouble men of our age, namely, the approach of death, which certainly cannot be long distant from old age."

After carefully going through the above exercises, the student should be sufficiently adept to be able to start the course of reading indicated in the Bibliography that follows. The one point on which emphasis must be laid is that the whole system falls to the ground unless scrupulous care is taken not to let the attention, or even the eye, pass from a word to what follows it until all the possibilities of its meaning have been reviewed.

COURSE OF READING

The following bibliography is an attempt to indicate a course of reading advisable for the student of Latin. For the titles see the section immediately following on *Books to Read*.

The articles on Accidence and Syntax contained in this volume are sufficient to give a working knowledge of the subject with which to start reading the classics. For a fuller and more scientific treatment, reference may be had to *Gildersleeve* and *Riemann*, but only after a long course of reading has made the student familiar with the written language. *Kennedy* and *Roby* are more elementary books, and may be turned to for the difficulties which are met in the earlier stages.

For composition, the student should work through *Macmillan's Course*, and then go over the ground again in *Browne* and *Hagarty*, or *Postgate*. The keys should be used only for the purpose of correction, and after correction

each exercise should be retranslated without the key.

It is important to remember that the only way in which to learn to write Latin is by reading it, and the best matter for reading is the Latin authors themselves.

Caesar, Nepos, and *Ovid,* having the simplest style, should form the beginning of the course of reading. When they can be read with ease, the student can go on to *Livy* and *Vergil. Cicero* should form the next stage, after which the student may suit his own taste.

The editions given below are those considered of most use to the student consonant with lowness of price; the price stated is in each case nett.

For the study of literature, *Mackail* is the shortest and easiest book for a beginning. *Tyrrell* should follow, and then others may be read as they come.

Dictionaries.—The only satisfactory way to work is to use *Lewis and Short,* which gives the use of each word by different authors. For reading, a smaller dictionary may be used, but for composition, after the student has begun to do continuous pieces, *Lewis and Short* is essential if classical Latin is to be written.

The English-Latin dictionary should be most sparingly used. It is very rarely that an English phrase has an exact Latin equivalent, and dependence on an English-Latin dictionary spells ruin for all hopes of writing good Latin.

Books to Read

ACCIDENCE AND SYNTAX.

Roby. School Latin Grammar. Macmillan. 3*s.* 9*d.*
Kennedy. Revised Latin Primer. Longmans. 1*s.* 11*d.*
Gildersleeve and Lodge. Latin Grammar. U.S.A. 4*s.* 6*d.*
Riemann. Syntaxe Latine. France. 5*fr.*

Of these, Kennedy is the most elementary and best suited to beginners.

PRONUNCIATION.

Arnold and Conway. Cambridge. 1*s.*

DICTIONARIES.

Latin-English.
Lewis and Short. Oxford. 18*s.* 9*d.*
Smith. Smaller Latin-English Dictionary. Murray. 5*s.* 8*d.*
English-Latin.
White. Longmans. 2*s.* 3*d.*
English-Latin and Latin-English.
White. Longmans. 3*s.* 9*d.*

COMPOSITION.

Hagarty. First Latin Reader. Morany.
Macmillan. Latin Course. 3 vols. 6*s.* 5*d.*
Browne. Handbook to Latin Composition. 3*s.*
Browne. Handbook to Latin Composition. Key. 5*s.*
Postgate. Sermo Latinus. Macmillan. 2*s.* 8*d.*
Postgate. Sermo Latinus. Macmillan. Key. 6*s.*

TRANSLATION.

Jerram. Anglice Reddenda. Oxford. 1*s.* 6*d.*

LITERATURE: (A) *Introductions.*

Mackail. Latin Literature. Murray. 2*s.* 8*d.*
Tyrrell. Latin Poetry. Macmillan. 3*s.* 5*d.*
Sellar. Poets of the Republic. Clarendon Press. 7*s.* 6*d.*
Poets of the Augustan Age. Clarendon Press. 10*s.* 6*d.*
Horace and the Elegiac Poets. Clarendon Press. 10*s.* 6*d.*
Nettleship. Essays in Latin Literature.

(B) *Authors.*

Caesar: De Bello Gallico.—St. G. Stock. Clarendon Press. 8*s.* 3*d.*; Bond & Walpole. Macmillan. 3*s.* 5*d.*; Bk. 1. Merryweather. Longmans. 1*s.* 1½*d.* Bks. 2 and 3. Merryweather. Longmans. 1*s.* 1½*d.*
De Bello Civili.—Bk. 1. Bensley. Bell. 2*s.* 6*d.*

Catullus: Selected Poems. Simpson. Macmillan. 2*s.* 8*d.*

Cicero: Catiline Orations.—Wilkins. Macmillan. 1*s.* 11*d.*
Pro Archia.—Reid. Pitt Press. 1*s.* 6*d.*
Pro Milone.—Reid. Pitt Press. 1*s.* 11*d.*
Pro Lege Manilia.—Nicol. Pitt Press. 1*s.* 2*d.*
De Senectute.—Huxley. Clarendon Press. 1*s.* 6*d.*
Select Letters.—Tyrrell. Macmillan. 3*s.* 5*d.*
Philippic II.—Peskett. Pitt Press. 2*s.* 8*d.*

Cornelius Nepos.—Shuckburgh. Pitt Press. 4 vols. Each 1*s.* 2*d.*

Horace: Odes and Epodes.—Page. Macmillan. 3*s.* 9*d.*
Satires.—Palmer. Macmillan. 3*s.* 9*d.*
Epistles.—Wilkins. Macmillan. 3*s.* 9*d.*
Translation:—Wickham. Clarendon Press. 3*s.* 6*d.*

Juvenal.—Duff. Pitt Press. 3*s.* 9*d.*

Livy: Bks. I, II, IV, V, VI, IX, XXI, XXII, XXVII.—Pitt Press. Each 1*s.* 11*d.*
Bk. XXI.—Trayes. Bell. 2*s.* 6*d.*

Lucan: Pharsalia. Bk. I.—Heitland. Pitt Press. 1*s.* 2*d.*
De Bello Civili. Bk. VII.—Postgate. Pitt Press. 1*s.* 6*d.*

Lucretius. Bks. III and V.—Duff. Pitt Press. Each 1*s.* 6*d.*

Martial: Select Epigrams.—Stephenson. Macmillan. 3*s.* 9*d.*

Ovid: Selections.—Ramsay. Clarendon Press. 4*s.* 2*d.*

Plautus: Captivi.—Lindsay. Clarendon Press. 1*s.* 11*d.*
Trinummus.—Freeman. Clarendon Press. 2*s.* 3*d.*
Miles Gloriosus.—Tyrrell. Macmillan. 2*s.* 8*d.*

Pliny: Selected Letters.—Prickard. Clarendon Press. 2*s.* 3*d.*

Propertius: Select Poems.—Postgate. Macmillan. 3*s.* 9*d.*
Propertius and Tibullus.—Ramsay. Clarendon Press. 4*s.* 6*d.*

Quintilian: Inst. Or. Bk. X.—Peterson. Clarendon Press. 2*s.* 8*d.*

Sallust: Catiline and Jugurtha.—Merivale. Macmillan. 2*s.* 8*d.*

Tacitus: Agricola and Germania.—Church and Brodribb. Macmillan. 2*s.* 8*d.*
Annals I–IV.—Furneaux. Clarendon Press. 3*s.* 9*d.*
Histories.—Bks. I, II, and III–V. A. D. Godley. Macmillan. Each 2*s.* 8*d.*

Terence: Comedies.—Papillon. Longmans. 3*s.* 5*d.*

Vergil: Bucolics; Georgics, I, II, III, and IV; Aeneid I–XII—each book separately, Macmillan. (Elementary Classics Series.) 1*s.* 2*d.*

Note.—Translations of most of the above texts can be obtained in the "Tutorial" series at a negligible cost.

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FRENCH

HOW TO USE THIS ARTICLE

If this article is to be in any way a manual of a language, it must provide the reader with some kind of exercises in the different constructions of the language: otherwise he will read it but get no permanent value from it.

Now, to set exercises in conjunction with each section of this work would turn it into a school-book at once, and probably occasion a certain distaste for it. The writer, then, proposes the following plan, by which the reader should make himself familiar with the subject-matter in the most systematic way.

In the first place, he should provide himself with a fair-sized exercise book, and number the pages according to the sections. This numbering should be done gradually, so that the reader may know what space to allow himself. Then, after reading any introductory matter there may be, he should study the extracts very carefully, comparing them with the translation annexed, and reading them through aloud several times. It would also be a good thing to copy out the French several times—not, however, in the exercise book. He should then collect and tabulate instances of the construction or rule being dealt with—*e.g.* Plural of Nouns, Agreement of Adjectives, Tenses of Verbs (tabulated in Conjugation), and so forth. When a rule has been stated in summary at the end of a section, he should copy it out against the section number in his exercise book. Where forms are given—*e.g.* of Verbs or Pronouns—he should memorise them carefully.

He should then take the translation of the earlier extracts and endeavour to put them back into French. He should, of course, let a reasonable time elapse between looking at the French and attempting the re-translation (the ideal being a night in between).

When the version he has made has been compared with the original, a fair copy should be made of it in the exercise book. The amount of vocabulary he should provide himself with before starting an attempt at a translation must depend on the individual. A quick, retentive mind will remember most of the words, and will only require a list of the verbal forms occurring in the passage. After the section on verbs has been done, this need should cease. The mind less at home in letters should make a list of the other words he may require for the composition, and should put an M. or F., as the case may be, against the nouns, to show what gender they are.

It may be found preferable not to work through the whole of the article in detail at first. In this case the sections marked ** may be taken first, and the extracts marked * only attempted.

In this way it may be claimed that the study will be endowed with considerable interest, and will not involve meaningless tedium. To obtain an active vocabulary—*i.e.* one in which the French for a word comes to the mind willingly—it is useful to try to reproduce extracts orally, phrase by phrase.

For those who wish to acquire some facility in spoken French it is absolutely necessary that they get a Frenchman or some qualified person to put them on the right road in pronunciation. The best thing to do is to read passages of French with this tutor, for reading is the safest way to speaking. But it is not sufficient to be taught the pronunciation of a word or phrase by itself: what is necessary is to be taught the sound, and then when this sound comes again it will be recognised and pronounced in the same way. (See Pronunciation Section.)

FOR THOSE BEGINNING TO SPEAK FRENCH

Of course, the first need is a vocabulary. If anyone wishes to begin to speak from the first, he must provide himself with some phrase-book or vocabularies (such as Professor Spiers' well-known series), and learn lists by heart; and he must at the same time learn the indicative mood of the verbs, both directly and interrogatively and negatively. For this is the crux of speaking in the early stages—to put a verb into, say, the questioning form, perhaps in a compound tense, and at the same time perhaps to put the pronoun object in its place in front of the verb. To take an instance. You are demanding your shoes in the morning from the attendant in a Paris hotel. Now it is true that if you have a touch of the superman you will yell 'May sooliay' till you get them. But if you allow yourself to listen to the explanations of the waiter, and if you try to relate the facts in a rational way to him and to answer any questions he may ask you, the conversation will go on something like this: you lead off

with, 'Où sont mes souliers ?' He replies, 'Monsieur ne les a pas ?' He would think it rude to call you 'You,' so he says 'Monsieur,' alluding to you, and he makes the question in an affirmative form, conveying the question by the intonation. However, he will know that you have not got them, since you are asking for them. You now start off with an explanation of how you put them outside your door the night before, and you say, 'Je placay'—you have forgotten that 'mettre' is *put ;* and if you have not, you are far too wise to embark on a nasty irregular verb like that. 'Je placay,' you resume, and then your mind goes hunting for *them* in French ; perhaps you arrive at 'les'—yes, 'Je placay lay.' *Outside the door* is clearly beyond your powers, but your native English common-sense coming to your rescue, you say boldly, 'à la porte.' 'Pré-ci-se-ment-mon-si-eur-je-le-sai-bi-en-ra-ma-ssé-ce-ma-tin-et-je-crois-le-sa-voir-rempla-cé-à-hui-t-'eu-res.' You are now hopelessly out of your depth. If you try to unravel all that, you will require the whole morning. The injured father in *L'anglais tel qu'on le parle* distributes half-sovereigns at this stage, but that is always easier on the stage than in real life.

Perhaps you get him to start again, holding his arm to check him when necessary. 'JE LES AI BIEN RAMASSÉ CE MATIN, ET JE CROIS LES AVOIR REMPLACÉ À HUIT HEURES.'

'Je les ai bien ramassé.' He uses the compound tense, and he puts the *them* in front of the *have*. Now, if you are going to shut yourself up in your bedroom till you are master of that style of thing, you must in the first place be able to give any tense of an ordinary verb almost automatically, and you should be able to turn all the *yous* round if necessary, and say 'vous mangez' or 'mangez-vous,' 'vous avez mangé' or 'avez-vous mangé,' equally rapidly. You must also learn to put the *nots* into their right places, so : 'Je ne mange pas,' 'vous ne mangez pas,' etc. etc. ; and you must learn to put a pronoun object in at intervals. Thus : 'Je *vous* ai vu,' 'vous m'avez vu,' etc. The more thoroughly this is done, the more subsequent advantage you will get from it. The three tenses of primary importance are the Present, the Future, and the Past Indefinite, which is the ordinary conversational tense for past actions, though the Imperfect—which 'will do'—has this advantage, that four forms out of the six are identical.

A working knowledge of the verb is by far the most important consideration in starting to speak a foreign language. Mistakes in the gender of nouns or adjectives do not cause the deadlock that inability to 'predicate' a thing does.

Note.—We saw that the 'garçon,' in making the statement which knocked 'you' out, made it all the more deadly by running his words together—or speaking 'so fast,' as the foreigner expresses it. This difficulty can only be overcome by accustoming the ear to interpret French sounds by reading aloud, by getting a competent person to read to you and to talk to you.

I. INTRODUCTORY LESSON

The following extract is intended as a pronunciation extract, and also as an illustration of the simplest and most frequently occurring grammatical rules. The beginner should study carefully and master the principles explained below, as they will be found to be of the widest application and to constitute the base of most of what follows. Too much stress need not be laid on the translation, so long as the meaning is roughly grasped. It will be very useful to commit the piece to memory, and, if possible, the learner should get a competent person to exercise him in the pronunciation. (See Pronunciation Section for reading aloud.)

LES DJINNS PAR VICTOR HUGO	THE GENIES BY VICTOR HUGO
1. *Murs*, ville Et port, Asile De mort, Mer grise Où *brise* La brise. Tout *dort*.	Walls, town And port, Asylum Of death, Sea grey Where breaks The breeze. All sleeps.
2. Dans la plaine *Naît* un bruit. *C'est* l'haleine De la nuit. Elle brame Comme une âme Qu'une flamme Toujours suit.	In the plain Springs up a sound. 'Tis the breath Of the night. It wails Like a soul Which a flame Follows aye.
3. La rumeur approche, L'écho la re-dit. *C'est* comme la cloche *D'un* couvent maudit, Comme un bruit de foule Qui tonne et qui roule, Et tantôt s'écroule, Et tantôt grandit.	The rumour approaches. The echo repeats it. It is as the bell Of a convent accursed, As a noise of a crowd Which thunders and rolls, And now falls away, And now swells forth.
4. C'est l'essaim des Djinns qui passe Et tourbillonne en *sifflant*. Les ifs que leur vol fracasse, Craquent comme un *pin brûlant*. Leur *troupeau lourd* et *rapide*, *Volant* dans l'espace *vide*, Semble un nuage vide Qui porte un eclair *au flanc*.	'Tis the swarm of the Genies Which passes whirling and hissing. The yews which their flight shivers Crack like a burning pine. Their herd, heavy and rapid, Flying in empty space, Seems a hollow cloud Bearing the lightning in its flank.
5. Cris de l'enfer ! voix qui hurle et qui pleure : L'horrible essaim, *poussé* par l'aquilon, Sans doute, Ô ciel ! *s'abat* sur ma demeure. Le mur fléchit sous le noir bataillon. La maison crie et chancelle *penchée*, Et l'on dirait que, du sol *arrachée*, Ainsi qu'il chasse une feuille *sechée*, Le vent *la* roule avec leur tourbillon !	Cries infernal ! Voices which howl and weep ! The awful swarm, by the North wind urged on Doubtless, O Heaven ! dashes itself on my abode. The wall bends beneath the dark battalion. The house groans and slanting staggers, And one would say that, torn up from the soil, As it might chase a withered leaf, The wind rolls it along with their whirl.

6. Ils sont *passés!* Leur cohorte	They are past! Their cohort
S'envole et fuit et leurs pieds	Recedes and flies, and their feet
Cessent de battre ma porte	Cease to beat at my door
De leurs coups *multipliés.*	With their strokes repeated.
L'air est plein d'un bruit de chaînes,	The air is full of a noise of chains,
Et dans *les* forêts *prochaines*	And in the forests hard-by
Frissonnent tous les *grands* chênes,	Shiver all the great oak-trees
Sous leur vol de feu *pliés!*	Beneath their fiery flight inclined.
7. *D'*étranges syllabes	Strange syllables
Nous *viennent* encore:	Come to us still:
Ainsi des arabes	Thus from the Arabs
Quand sonne le cor,	When the trumpet sounds,
Un chant sur la grève	A song on the strand
Par instants s'élève,	At instants arises,
Et l'enfant *qui* rêve	And the child who dreams
Fait *des* rêves d'or.	Has golden dreams.
8. Les Djinns funèbres,	The Genies of the grave,
Fils *du* trépas,	Sons of death,
Dans les ténèbres	In the darkness
Pressent leurs pas;	Urge on their steps:
Leur essaim gronde:	Their swarm growls:
Ainsi, profonde,	As profoundly
Murmure une onde	There moans a wave
Qu'on *ne* voit *pas.*	Which one sees not.
9. Ce bruit *vague*	This vague sound
Qui s'endort,	Which dies away,
C'est la vague	'Tis the billow
Sur le bord;	On the shore;
C'est la plainte	'Tis the call,
Presqu'*éteinte*	Almost hushed,
D'une sainte	Of a saint
Pour un mort.	For one dead.
10. *On* doute	One doubts
La nuit . . .	(Of) the night . . .
J'écoute:	I listen:
Tout fuit,	All is flying,
Tout passe;	All passes;
L'espace	And space
Efface	Effaces
Le bruit.	The sound.

NOTES TO 'LES DJINNS'

v. 1. 'murs.' The *s* in 'murs,' as in 'Djinns,' shows that in French, as in English, *s* is the sign of the plural. ll. 6–8, 'brise . . . dort.' In English *breaks* and *sleeps* end in *s*. Why? To indicate that a singular subject is being spoken of. In French the sign is *e* or *t*.

v. 2. 'naît.' *t*-ending again. Collect all the instances of both endings. l. 2, 'un,' but in l. 6 'une.' Why? In French, *a* or *the* show the gender. 'Un' with a 'male' word, 'une' with a 'female' word. 'La' with a female—'la plaine'—'le' with a male. v. 5. 'le mur,' 'le vent' (*l'* before a vowel sound). Collect instances.

v. 3, l. 3. 'c'est . . . d'un.' An unaccented *e* has been slurred here. This is usual. Collect instances. 'la redit.' This is the regular order when the object is a personal pronoun.

v. 4, l. 2. 'sifflant,' and 'brûl-ant' in l. 4, with 'vol-ant' in l. 6, indicate that the verbal ending *-ant* in French is the equivalent of the English *-ing*. 'craquent.' This is the plural form of 'craque.' l. 4. 'pin brûlant.' Note order, and compare with 'troupeau lourd' in next line, and also with 'couvent maudit' in v. 3, l. 4. Customary in French. l. 8. Why 'au'? We shall see later.

v. 5. Why 'l'enfer,' *the* hell? In French an article usually accompanies the noun. Thus 'voix' would probably be 'une voix' in prose. l. 2. Notice 'poussé,' *pushed*, and in ll. 5, 6, 7, 'penchée,' *tilted*; 'arrachée,' *snatched*. Are these corresponding endings? Yes. The *-é* has the force of the English *-ed* as the sign of the past participle, in verbs which make the 3rd singular present in *-e*. l. 3, 's'abat.' Why is the *s* there? It means *itself*. In French many verbs are made reflexive, as it is called, where in English there seems no need.

v. 6, ll. 3, 4, 5. Does 'de' mean *to*, *with*, and *of*? No; but it does in these cases. ll. 3, 5. Notice plural verbs 'cess-ent' and 'frissonn-ent.' ll. 6, 7, 'les.' This is the plural form of 'le' or 'la.' Moreover, the adjectives 'prochaines' and 'grands' also add an *s*. We say that they agree with the nouns they accompany. 'prochaines' shows that it agrees in gender too ('forêts' is a feminine word) by adding an *e* to the masculine form, 'prochain.' If the adjective ends in an unaccented *e* already, as 'rapide' and 'vide' in v. 5, it remains unchanged. This *agreement* accounts for the *-s* at the end of 'passés' (l. 1), which is looked on as an adjective, and in 'pliés' (l. 8). All instances should be collected, as this is a very common rule.

v. 7, l. 1. 'D''—*i.e.* 'de'—here has another meaning, untranslated in English. (See next note.) l. 3. 'des,' short for 'de les,' *of the*. l. 8, 'des' here again means *some*. The truth must now out. Two things must be said. In French 'de le' is written 'du,' and 'de les' is written 'des.' (At the same time, it may as well be said that 'à le' is written 'au,' as we saw in 'au flanc' (v. 4, l. 8), and 'à les' becomes 'aux.' 'De l'' and 'à l'' do not alter.) Moreover, the French have a passion for precision—'on dit'—and this manifests itself in their always stating, when they are speaking of any persons or things, whether they mean *all* or *some*, the *general* or the *particular*. Now the expression they have consecrated to render this *some* is the one used to stand for *of the*. The general is expressed, it may be added, by the 'le,' 'la,' 'l',' or 'les,' as the case may be.

v. 8, l. 2. 'du.' An instance of the contraction of 'de le.' l. 7. A poetical inversion. The normal order would be 'une onde murmure.' l. 8. 'Qu'on ne voit pas,' *which one sees not*. Compare the French and English way of making a negative statement. We use the verb *do*, except with *am*, *is*, *are* (the various parts of the verb *to be*), and verbs such as *have*, *can*, *will*, etc.; the French negative by inserting 'ne' before and usually 'pas' after it. The force of 'ne . . . pas' is similar to our *not at all*. l. 6. 'éteinte' has the feminine *e*-ending, in agreement with 'la plainte.'

v. 10, l. 1. 'On,' *one*, is used much more in French than in English. When speaking

generally, we use a pronoun of any person—*you never can tell; they say*. In French 'on' is always used. The preciseness of the language demands that an indefinite word shall introduce an indefinite statement. Thus *On ne peut jamais dire* was the title under which Shaw's play was presented in Paris. *On ne saurait penser à tout* is a similar title of a play of Musset. *They say* is '*on dit*' (l. 3). 'j'écoute.' The ending of the 1st person of the verb (present tense) is the same as the 3rd with verbs which make that ending *e*.

We will now summarise the commonest rules we have obtained.

1. To form the plural nouns add *-s* to the singular, as a rule.

2. Adjectives 'agree' with their nouns in gender and number. An adjective becomes feminine by adding *-e*, and plural by adding *-s*, to the masculine singular. Adjectives ending in an unaccented *-e* do not add an *e* to form the feminine. Similarly, adjectives ending in *s* in the masculine do not add an *s* to form the masculine plural.

3. We have obtained the following verbal forms for the present tense: 'j'écoute,' 'elle brame,' 'il chasse,' 'on doute,' in the 1st and 3rd persons singular; and also a number of forms of the 3rd singular in *-t*: 'suit,' 'grandit,' 'fuit,' etc. In the 3rd person of the plural we have invariably found the form in *-ent*: 'craqu-ent,' 'frissonn-ent,' 'vienn-ent,' 'press-ent,' etc. Note, however, the exception 'sont,' *are*, plural of 'est,' *is*.

4. The forms 'vol-ant,' 'siffl-ant,' 'brul-ant' equal the English *fly-ing*, *hiss-ing*, *burn-ing*, the participle present.

5. The forms 'poussé,' 'penchée,' 'sechée' give examples of the past participle ending, corresponding to the English *pushed*, *tilted*, *dried*. We have, however, found 'éteinte,' *hushed*, and 'maudit,' *accursed*. The verbs which make their past participles in *e* belong to the same class as those which form the present tense, 1st and 3rd persons singular, in *-e*. The forms 'maudit' and 'éteinte(e)' belong to the class of verbs such as 'suit,' 'grandit.'

6. 'De le' becomes 'du.' 'De les' becomes 'des.' 'À le' becomes 'au.' 'À les' becomes 'aux.' 'De l',' 'à l',' 'de la,' and 'à la' do not alter.

7. A French noun generally is accompanied by an Article. Where we say *fire and water*, *justice and truth*, the French say 'le feu et l'eau,' 'la justice et la vérité.' When a thing is referred to in part, this is expressed in French.

8. A negative statement is made in French by the word 'ne' being put before the verb, and a complementary term, usually 'pas,' after it.

9. The participle, being a verbal adjective, is treated as an adjective in the question of 'agreeing' with the noun to which it refers, unless it is used in a more verbal manner.

10. The personal pronoun object precedes the verb.

We will now take another example. It is from Daudet, the great French humorist. 'Le voici,' *here it is*:

Il faut vous dire qu'en Provence c'est l'usage quand viennent les chaleurs d'envoyer le bétail dans les Alpes. Bêtes et gens passent cinq ou six mois là-haut logés à la belle étoile dans l'herbe jusqu'au ventre. Puis au premier frisson de l'automne on revient. . . . Donc hier soir les troupeaux rentraient. Depuis le matin le portail attendait. Les bergeries étaient pleines de paille fraîche. D'heure en heure on se disait, Maintenant ils sont à Eguyères, maintenant au Paradou. Puis tout à coup vers le soir un grand cril Les voilà . . . et là-bas au lointain nous voyons le troupeau s'avancer. Toute la route semble marcher avec lui.	It is necessary to tell you that in Provence it is the custom when the 'heats' come to send the cattle into the Alps. Beasts and folk pass five or six months up there lodged 'beneath the stars,' in the grass up to the belly. Then at the first shiver of autumn they return. . . . Well, yesterday eve the flocks came back. Since the morning the gate was awaiting them. The folds were full of fresh straw. From hour to hour one told oneself, Now they are at Eguyeres, now at Paradou. Then all at once towards the evening a great cry, Here they are. . . . And away there in the distance we see the troop advancing. All the road seems to march with it.

We will notice the occurrence of the rules we have already discovered, and also any new ones which may present themselves.

l. 1. 'Il faut,' *it needs*, *it is necessary*. This is an impersonal verb, a much commoner thing in French than English. 'Il' stands for *it* as well as for *he* in French. 'C'est,' *this is*; we say, *it is*.

'vous dire,' *to tell you*. In French a personal pronoun, when it is an object of a verb, is put before that verb.

l. 3. 'd'envoyer.' Why 'd''? The expression is 'c'est l'usage d'envoyer,' *the custom of sending*. In French the Infinitive is the verbal noun which in English is rendered by *send-ing*.

'logés.' Notice that 'logés,' a participle, is looked on as an adjective, and takes the plural *-s* in agreement with 'bêtes et gens.'

l. 6. 'à la belle étoile' is an idiom.

Notice 'l'usage,' 'l'herbe,' 'l'automne.' Why 'l''? Abbreviation of 'le' and 'la' before a vowel. So (l. 4) 'au ventre' and 'au premier frisson,' 'au' for 'à le.'

So far the story has been in the present tense, and the chief forms have been the 3rd plural ('reviennent' and 'passent'). In the next few lines we find 'les troupeaux rentraient . . . le portail attendait . . . les bergeries étaient . . . on se disait.' These endings, '-ait' and '-aient,' are the marks of the imperfect tense, the tense of the past which denotes continued action, or state. It is rendered in English sometimes by the form *was —ing*, *were —ing*, or by the simple past.

l. 12. 'paille fraîche.' The adjective here follows its noun. 'Fraîche' is an irregular feminine form. The masculine is 'frais.'

l. 13. 'D'heure en heure (on se disait).' This is an idiomatic form.

We will now take a short piece of prose, the subject of which will be probably well known to everyone. 'Le voici,' *here it is :*

Trois jours après on faisait des noces à Cana en Galilee, et la mère de Jésus y était. Et Jésus fut aussi convié aux noces, *lui* et ses disciples. Le vin ayant manqué, la mère de Jésus *lui* dit, Ils n'ont pas de vin. Mais Jésus *lui* repondit, Femme, qu'y a-t-il entre moi et toi? Mon heure n'est pas encore venu. Sa mère dit à ceux qui servaient, Faites tout ce qu'il vous dira. Or il y avait là six vaisseaux de pierres mis pour servir aux purifications des Juifs, et qui tenaient chacun deux ou trois mésures. Jésus *leur* dit, Emplissez d'eau ces vaisseaux, et ils *les* emplirent jusqu'au haut. Et il *leur* dit, Puisez maintenant et portez-en au maître d'hôtel. Et ils *lui* en portèrent. Quand le maître d'hôtel eut goûté l'eau qui avait été changé en vin (or il ne savait pas où ce vin venait, mais les serviteurs qui avaient puisé l'eau *le* savaient bien), il appela l'époux et il *lui* dit, Tout homme sert d'abord le bon vin et ensuite le moindre, après qu'on a beaucoup bu. Mais *toi*, tu as gardé le bon vin jusqu'à présent.

Three days after they made a marriage at Cana in Galilee, and the mother of Jesus was there. And Jesus was also invited to the marriage, He and His disciples. The wine having failed, the mother of Jesus told Him, They have no wine. But Jesus answered her, Woman, what is there between Me and thee? My hour is not yet come. His mother said to those who served, Do all that He shall tell you. Now there were there six vessels of stone, put to serve for the purifications of the Jews, and which held each two or three measures. Jesus said to them, Fill with water these vessels, and they filled them to the brim. And He said, Draw out now and bear to the master of the feast. And they bore to him. When the master of the feast tasted the water which had been changed into wine (now he did not know whence this wine came, but the servants who had drawn the water knew quite well), he called the bridegroom and said to him, Every man serves first the good wine and then the less, after one has drunk plenty. But thou, thou hast kept the good wine until now.

It will be seen that there exist several forms for the personal pronouns in their various cases and uses. Thus we have, after a preposition, 'moi,' 'toi' (1st and 2nd), and 'lui,' 'leur' (3rd person indirect object). 'Lui' is also used when the pronoun is in an emphatic position, 'lui et ses disciples.' We shall explain these different uses when we deal with the pronouns in detail. Let it suffice for the present to note the existence of these different forms. Tabulated, they are :

First Person (je).—Emphatic 'moi': pronominal adjective 'mon.'
Second Person (tu).—Emphatic 'toi'; plural 'vous.'
Third Person (ils).—Object 'le,' plural 'les'; indirect object 'lui'; plural 'leur'; emphatic 'lui'; pronominal adjective 'sa,' plural 'ses.'

This last difference points out to us that the possessive adjective takes its gender and number from the thing possessed, not from the possessor.

But it is the verbal forms which will occupy us most in this passage. We notice two recurring features: first, the appearance of the endings '-ait,' '-aient,' in what the English tells us is a past tense. Secondly, that, as in English, tenses are formed, compounded of the verbs 'avoir,' *have*, and 'être,' *to be*. Thus we have: 'Fut convié . . . est venu . . . eut goûté . . . avait été changé . . . avaient puisé . . . on a bu . . . tu as gardé,' and the participle 'ayant manqué.' Note that 'fut convié' is passive, and that 'est' is used to form the compound past tense of 'venu' (*cp.* English *is come*).

At the same time we have present forms—'ont,' 'faites,' 'emplissez,' 'puisez,' 'portez,' 'sert'—and another past tense form in 'dit,' 'répondit,' 'emplirent,' 'portèrent,' and 'appela.' It will be seen that the variety of forms for the verb in French demands a special and detailed study.

PHONETIC OF LES DJINNS (see p. 237)

1. MUR VI L^{e}
É PÓR
À ZI L^{e}
D^{e} MÓR
MÈR GRI Z^{e}
OU BRI Z^{e}
LÁ BRI Z^{e}
TOU DÓR

2. DA^{n} LÁ PLE N^{e}
NÈ TŒ^{n} BRUI
SÈ LÁ LÈ N^{e}
D^{e} LÁ NUI
EL BRÀ M^{e}
KÓ MU NÀ M^{e}
KU N^{e} FLÀ M^{e}
TOU JOUR SUI

7. DÉ TRA^{n} J^{e} SI LÁ B^{e}
NOU VIE^{n} TA^{n} KÓR
E^{n}SI DÈ SÁ RÁ B^{e}
KA^{n} SÓ N^{e} L^{e} KÓR
Œ^{n} CHA^{n}||SUR LÁ GRÈ V^{e}
PAR E^{n} STA^{n}||SÉ LÈ V^{e}
É LA^{n} FA^{n}||KI RÈ V^{e}
FÉ DÉ RÈ V^{e} DÓR

9. S^{e} BRUI VÁ G^{e}
KI SA^{n} DÓR
SÈ LÁ VÁ G^{e}
SUR L^{e} BÓR
SÈ LA PLE^{n} T^{e}
PRÈ SKÉ TE^{n} T^{e}
DU N^{e} SE^{n} T^{e}
POU R Œ^{n} MOR

8. LE JIN FU NÈ BR^{e}
FIS DU TRÉ PÀ
DA^{n} LÈ TÉ NÈ BR^{e}
PRÈ S^{e} LÈUR PÀ
LÈUR É SE^{n} GRO^{n} D^{e}
E^{n} SI PRÓ FO^{n} D^{e}
MUR MU RU NO^{n} D^{e}
KO^{n} N^{e} VWÁ PÀ

10. O^{n} DOU T^{e}
LA NUI
JÉ KOU T^{e}
TOU FUI
TOU PÀ S^{e}
LÉ SPÀ S^{e}
É FÀ S^{e}
L^{e} BRUI

II. THE PARTS OF SPEECH

In a language we talk about 'things,' and we say what happens to them. The most important parts of speech, then, are the *names* we give to things (*nouns*, as we say in English; in French, 'noms'), and the words for the happenings or actions the—*verbs* (French, 'verbes').

** 1. **The Nouns.**—(We can couple with the study of nouns that of adjectives, for they closely resemble them in form, and they are always associated with nouns in their use.)

We already know that the noun usually forms its plural by adding *-s* to the singular, and that the adjective does the same, as it agrees with its noun in number, while at the same time it 'agrees' in gender, if feminine, by adding an *-e* to the masculine form. We must also remember that, as there is no neuter in French, such nouns will go either into the masculine or the feminine class.

1. Let us now examine this extract with reference to the nouns and adjectives :

SAINT FRANCIS

C'était dans sa première jeunesse un homme de vanité, un bouffon, un farceur, un chanteur, léger, prodigue, hardi. . . . Tête ronde, front

ST. FRANCIS,

He was in his first youth a man of vanity, a buffoon, a joker, a singer, giddy, reckless, bold . . . (his) head round, forehead small, eyes

petit, yeux noirs, sourcils droits, nez fin et droit, oreilles petites et comme dressées, langue aiguë et ardente, voix véhémente et douce ; dents serrées, blanches, égales ; lèvres minces, barbe rare, col grêle, bras courts, doigts longs, ongles longs, jambe maigre, pied petit, de chair peu ou point. . . .—MICHELET.	black, eyebrows straight, nose fine and straight, ears small and as if pricked up, (with a) tongue keen and ardent, (the) voice vehement and soft; teeth close together, white and even, the lips thin, (a) scanty beard, a scraggy neck, short arms, fingers and nails long, a thin leg, (a) small foot, of flesh little or none. . . .

What do we find in this extract beyond the two cardinal rules that the plural is formed by adding an *-s*, and the feminine by adding an *-e*, to the normal masculine singular ? There is one unusual plural, 'yeux.' The singular is 'œil.'

In the adjectives, where gender shows itself more commonly, it will be useful to collect the masculine singular and plural, and the feminine singular and plural, with their nouns. Note 'prodigue' and 'aiguë.' The former must be masculine, as it refers to a man, while 'aiguë' is feminine ('ardente' shows that the noun 'langue' is so). 'Prodigue,' then, like 'mince,' 'rare,' 'grêle,' 'maigre,' is an instance of the rule that if the adjective already ends in an *-e* (mute), no additional *-e* is added for the feminine. The participles, 'dressées' and 'serrées,' which end in an accented *-é*, however, add the feminine *-e*. The writer has placed all his adjectives after their noun, although 'petit' as a rule comes before the noun (as does 'première'). As he is giving a list of characteristics, he drops the article, definite or indefinite, which would otherwise be required. Notice that 'première' is written with a grave accent. This is due to the rule of pronunciation, when a mute *-e* ends a word, that the previous vowel becomes grave by position. So 'leger' would make its feminine 'legère.' (*Cp.* p. 248.) Note 'douce' and 'blanches'—masculine 'doux,' 'blanc.' With regard to the gender of nouns, we notice that 'jeunesse' is feminine, and this suggests that *-esse* is a feminine ending (*princess*). This is so, and 'farceur,' 'chanteur,' have masculine endings (*cp.* English *sing-er*, *songstress*). Note also that all nouns ending in *-e* are feminine, except 'ongle,' and all ending in a consonant masculine, except 'dent.' This, however, is by no means a universal rule.

We will now take another example and treat it in the same way :

DANTON	DANTON
Un colosse à tête de 'Tartare,' d'une laideur *tragique* et *terrible*, un masque *convulsé* de bouledogue *grondant*, de *petits* yeux *enfoncés* sous les *énormes* plis d'un front *menaçant*, une voix *tonnante*, des gestes de combattant, une surabondance et un bouillement de sang, de colère et d'energie, une déclamation *effrénée*, pareille aux mugissements d'un taureau, des images *démesurées*, une emphase *sincère*, des tressaillements et des cris d'indignation *capables* de réveiller les instincts *féroces* dans l'âme la plus pacifique, et les instincts *généreux* dans l'âme la plus abrutie, un cynisme *jaillissant*, spontané et de source *vive*, des crudités *énormes* et dignes de Rabelais, une bonhomie *gouailleuse*, des façons *cordiales* et *familières*, *propres* à capter la confiance et les sympathies d'une plèbe *gauloise* et *parisienne*—un grand seigneur de la sans-culotterie.—TAINE.	A colossus with (a) Tartar head, of an ugliness tragic and terrible, the distorted visage of a growling bulldog, little eyes buried beneath the enormous folds of a scowling forehead, a thundering voice, aggressive gestures, a superabundance and a 'boiling over' of blood, of wrath and energy, an unrestrained manner of speaking, like the bellowings of a bull, (with) similes out of all proportion, a sincere emphasis, shudders and cries of indignation capable of awakening ferocious instincts in the most pacific soul and generous instincts in the most degraded (soul), an outspoken cynicism, spontaneous and genuine, crudenesses enormous and worthy of Rabelais, a jesting heartiness, manners cordial and familiar, fitted to capture the confidence and sympathy of a Gallic and Parisian people —a great lord of the 'unwashed.'

The Nouns.—There is nothing to attract our attention in the plurals, though we may wonder how 'taureau' and 'voix' would form their plural.

Collecting the nouns and classifying them by gender, we get the following :

Names of males : 'Colosse,' 'Tartare,' 'bouledogue,' 'taureau,' 'seigneur,' and 'combattant' (the latter being a participle used in the masculine).

Ending in a consonant (masculine) : 'yeux,' 'front,' 'sang,' 'instincts,' 'bouillements,' 'mugissements,' 'tressaillements.' (Nearly all nouns ending in *-ment* are masculine). 'Pli,' 'cri,' 'masque,' and 'cynisme' are also masculine—these last two although ending in an *-e* mute.

Feminines ending in *-e* mute are 'tête,' 'image,' 'emphase,' 'âme,' 'source,' 'sympathie,' 'sans-culotterie,' 'energie,' 'bonhomie' (*-ie* is nearly always a feminine ending), 'surabondance,' 'confiance' (*-ance* another feminine ending), 'déclamation,' 'indignation' (*-ation* always a feminine ending) ; while 'laideur,' 'voix,' 'façon' are exceptions to the rule that consonant endings are mostly masculine.

Adjectives.—We note 'terrible,' 'énormes,' 'sincère,' 'capables,' 'féroces,' 'dignes,' and 'propres' ending in the masculine in *-e* mute.

'Convulsé,' 'grondant,' 'enfoncés,' 'menaçants,' 'tonnante,' 'démesurées,' 'abrutie,' 'spontané,' are really participles used in an adjectival sense.

Now notice 'pareilles,' 'gouailleuse,' 'gauloise,' 'parisienne,' 'cordiales,' 'familières.' In each case it will be seen that the addition of the feminine *-e* has made the vowel of the preceding syllable grave. Hence in the vowel which shows the grave accent, 'parisiene' becomes 'parisienne' 'familiere' 'familières,' and 'pareil' 'pareille.' Doubling the consonant is an alternative way of expressing the force of a grave accent.

Note that 'généreux' is plural—that is to say, ending in *-x*, it does not alter in the plural. This is a general rule for nouns and adjectives ending in *-s*, *-x*, and *-z*.

'Vive.' What is the masculine of this ? Not 'viv.' Such a word might exist in Kalmuck, but not in French. The masculine is 'vif.' Final *-f* masculine always gives *-ve*.

'Gouailleuse.' The masculine is not 'gouailleus,' but 'gouailleur.' Another general rule :

-eur changes in feminine to *-euse*, but there are exceptions.

Note also the order of adjective in this piece. We can establish the following: (1) Participle adjectives always follow the noun. (2) When there are two or more adjectives, they both follow, unless one of them is an adjective usually put before the noun. (3) Adjectives of nationality come after the noun ('plèbe gauloise'), as do adjectives of colour, taste, etc. (4) Whether an adjective comes before or after is often decided by the ear: 'énormes plis,' but 'crudités énormes.'

To complete our observations, and to give further practice in the study of gender and number, we will take one more extract. (An intending martyr for the faith which he has just espoused apostrophises 'the world's offer.')

Source délicieuse en misère féconde,	Delicious source in misery rich.
Que voulez-vous de moi, flatteuses voluptés?	What will you from me, deceiving pleasures?
Honteux attachements de la chair et du monde,	Shameful attachments of the flesh and of the world,
Que ne me quittez-vous quand je vous ai quittés?	Why do you not leave me when I have left you?
Toute votre félicité, Sujette à l'instabilité,	All your happiness, subject to instability,
En moins de rien tombe à terre;	In less than nothing falls to (the) ground;
Et comme elle a l'éclat de verre, Elle en a la fragilité.	And as it has the glitter of glass, it has (too) its frailty.

Nouns with masculine endings are 'attachements,' 'plaisirs' (consonantal ending), and (contrary to the rule) 'monde' and 'verre.' Feminine are 'source,' 'guerre,' 'terre,' 'voluptés,' 'félicités,' 'instabilité,' 'fragilité,' 'honneurs' (*-eur*, a feminine ending), and (irregularly) 'chair.'

Masculine adjectives are 'honteux' (plural), of which the feminine would be 'honteuse,' as 'délicieuse.' 'Flatteuses,' on the other hand, is the feminine of 'flatteur' (*cp.* 'gouailleuses'). 'Sujette' doubles the final consonant to make its vowel grave. 'Toute' and 'votre' are normal, the latter a mute *-e*.

There is still one rule in the formation of plural nouns to be touched on. If you look at this extract:

La Providence a dispensé avec tant de sagesse les biens et les maux de la vie que chacun, quel que heureuse que sa destinée, trouve des croix et des amertumes, qui en balancent toujours les plaisirs.	Providence has dispensed with so much wisdom the good and the evil (things) of life that everyone, however happy his destiny, finds crosses and bitternesses, which always balance the pleasures thereof.

and then compare it with this one:

Tous les animaux ont la faculté de se mouvoir et de se porter ou de s'arrêter selon leur besoin.	All animals have the faculty of moving and carrying or stopping themselves according to their need.

you may be struck with the two plurals, 'les maux' and 'les animaux.' 'Animaux' must come from a singular, 'animal,' and this sug- 'maux' from 'mal' (a root found in *malady*). If you heard that 'chevaux' was the plural of 'cheval,' you would see that this was the common way for a plural to be formed from a singular ending *-al*. The origin of this is interesting. The letter *l* is one which easily becomes silent (cp. *palm*, *alms*), and in French this was shown by changing it to *u*. When the termination *-au* became plural it would be *-aus*, and in monkish writing *-us* was written *-x* for short. Thus the plural was written *-ax*, and then in course of time people, thinking there had been a misspelling, altered this to *-aux*. Hence the plural common in nouns and adjectives ending in *-al*. A few nouns have kept the *-als* plural, and 'travail' is a common word ending in *-ail* which makes its plural 'travaux.'

'Chou,' 'genou,' 'hibou,' are words ending in *-ou* with their plural in *-oux*.

Summarising the rules to be drawn from the observations we have made, we obtain the following:

Number.—The plural is generally formed by adding *-s* to the singular of noun or adjective. If the word ends in *-s*, *-x*, *-z*, it remains unaltered.

Nouns and adjectives ending in *-au* (and *-eu*) form their plural in *-x*, not *-s*.

Ending in *-al* they usually change to *-aux*.

Feminine adjectives of course remain, *-ale*, *-ales*.

'Travail' and a few other nouns ending in *-ail* make their plural also in *-aux*.

A few nouns in *-ou* make their plural *-oux* ('genou,' 'hibou,' 'chou,' etc.).

Gender.—Male things, of course, are masculine, and female feminine. What we know as neuter words must go into one of these two classes.

Nouns ending in a consonant, with few exceptions, are masculine.

Nouns ending in an *-e* mute are, with numerous exceptions, feminine.

Terminations are useful in determining the gender in some cases.

Nouns ending in *-ment*, *-age*, *-acle*, *-aire*, *-ere*, *-oire*, *-asme*, *-isme* are masculine. (Note that these cover many of the *-e* mute exceptions.)

Nouns ending in *-ance*, *-ation*, *-eur* (if an abstract noun) are feminine.

Adjectives.—The general rule is to form the feminine by adding *-e* to the masculine form. If the masculine already ends in *-e* mute, no change is made. If the adjective ends in certain consonants, some change is made for the sake of euphony. Examples: 'vi*f*,' 'vi*ve*'; 'heureu*x*,' 'heureu*se*'; 'ch*er*,' 'ch*ère*.' Doubled consonant: 'cruel-le,' 'ancien-ne,' 'net-te,' 'bon-ne,' 'pareil-le.'

2. Adjectives—Comparison.—There remains to treat of one use of adjectives, which does not come under the head of gender or number. It is the comparative use. As adjectives are used to denote the possession of a certain quality, it

often happens that this quality is denoted as being present to a greater or less extent. How is this done in French ? Here are some examples :

* 1. Trois fois en un siècle, sous Caligula, sous Néron, et sous Domitien, *le plus grand* pouvoir qui ait jamais existé tomba entre les mains d'hommes exécrables ou extravagants. . . . *Les plus terribles* secousses étaient inévitables. De là des horreurs qui ont été à peine dépassées par les monstres des dynasties mongoles. . . . *Les plus choquantes* ignominies de l'Empire venaient de l'Orient, et surtout de l'Egypte, qui était alors un des pays *les plus corrompus* de l'univers.	1. Three times in a century, under Caligula, under Nero, and Domitian, the greatest power which has ever existed fell into the hands of execrable or abnormal men. . . . The most terrible shocks were inevitable. Thence the horrors which have been hardly surpassed by the monsters of Mongol dynasties. . . . The most shocking ignominies of the Empire came from the East, and above all from Egypt, which was then one of the most corrupt countries of the universe.
Le véritable esprit romain, en effet, vivait encore. Un temps où se préparaient des esprits *aussi profondément honnêtes* que Quintilien, Pline le Jeune, Tacite, n'est pas un temps dont il faille désespérer. . . . Il y avait dans les maisons nobles d'admirables épouses, d'admirables sœurs. Fut-il jamais destinée *plus touchante que* celle de cette jeune et chaste Octavie, fille de Claude, femme de Néron, restée pure à travers toutes les infamies, tuée à vingt-deux ans, sans qu'elle eût jamais senti aucune joie ?—RENAN.	The real Roman spirit, indeed, still lived. A time when were being formed minds as profoundly honourable as Quintilian, Pliny the Younger, Tacitus, is not a time of which one needs despair. . . . There were in the noble houses admirable wives, admirable sisters. Was there ever fate more touching than that of the young and chaste Octavia, daughter of Claudius, wife of Nero, (who) remained pure amid all infamies, (and was) killed at twenty-two, without having ever tasted any joy ?

Again, in the 'Djinns' we have :

2. La voix *plus haute* semble un grelot d'un nain qui saute; c'est le galop.	2. The voice still louder is as a bell of a leaping elf ; 'tis the whirligig.

Here is another quatrain of Hugo :

3. L'immense empire attend un héritier demain : Qu'est-ce que le Seigneur va donner à cet homme, Qui, *plus grand que* César, *plus grand* même *que* Rome, Absorbe dans son sort le sort du genre humain ?	3. The immense empire awaits to-morrow an heir ; What is the Lord going to give to that man, Who, greater than Cæsar, even greater than Rome, Absorbs in his fate the fate of human kind ?
4. Nous sommes *moins offensés* du mépris des sots *que* d'être médiocrement estimé des gens d'esprit.—VAUVENARGUES.	4. We are less offended with the contempt of fools than with being meanly thought of by people of intelligence.
5. La France était *moins avancée* pour les arts de la paix *qu*'au XIVe siècle.—MICHELET.	5. France was less advanced (in) the arts of peace than in the fourteenth century.

We see from these extracts that the superlative—'le plus grand pouvoir,' 'les plus terribles secousses,' 'les plus choquantes ignominies'—is always rendered by the addition of 'le plus,' 'la plus,' 'les plus,' and that the comparative is expressed by 'plus' alone. If you say a thing is most terrible, most shocking, or what not, the comparison with other things need not be expressed ; but if you only say it is more terrible, you must say *than* what. We see in 1 and 3 that this is rendered by 'Fut-il jamais destinée plus touchante que celle' . . . 'plus grand que César, plus grand même que Rome.' In 2, 'la voix plus haute,' the meaning is that the voice is 'plus haute' than it was before; so comparison is understood. Comparison may be of equality, as in 1, 'des esprits aussi . . . honnêtes que Quintilien.' The formula here is, we see, 'aussi . . . que . . .'

In 4 and 5 we have a comparison of inferiority : 'Nous sommes moins offensés . . . que,' *we are less offended . . . than.* 'La France était moins avancée . . . que.' Here 'plus que' is replaced by 'moins que.'

To sum up, then, we find that comparison in French is shown logically and clearly by the words 'plus' and 'moins' (*more* and *less*), which denote it, and the superlative by the convention of prefixing the article to 'plus.' Only in a few cases is the comparative expressed as in English, by a suffix being added to the positive adjective. These exceptions are 'meilleur,' *better ;* 'pire,' *worse ;* and 'moindre,' *less.* Their superlative is formed by prefixing the article in the usual way.

3. The Definite Article.—In our introductory lesson we saw that the use of the article was a little different in French to the English use. It is necessary to go into this difference somewhat more fully. Any passage of French will illustrate the point. Take, for instance, De Musset's little poem.

La vie est vaine : Un peu d'amour, Un peu de haine, Et puis Bonjour.	Life is vain : A little love, A little hate, And then Good-day.
La vie est brève : Un peu d'espoir, Un peu de rêve, Et puis Bonsoir.	Life is short : A little hope, A little dream, And then Good-night.

Here we see clearly how with a term stated 'generally' the French use the definite article, and say 'la vie,' *the life*, where we say simply *life*. On the other hand, we see, in the case of 'amour,' 'haine,' etc., they drop the article. 'Bonsoir,' 'Bonjour,' of course, are elliptical expressions.

Let us take a few more examples. 'En voici,' *here are some of them :*

L'hypocrisie est un hommage que le vice rend à la vertu.—ROCHEFOUCAULD.	Hypocrisy, we say, is a homage which vice renders to virtue.
L'homme est un roseau, mais c'est un roseau pensant.—PASCAL.	Man is a reed, but 'tis a thinking reed.

These examples are enough to establish that when a thing is taken 'generally,' the French always use the article. It is a point of interest to anyone familiar with logic to notice that in French the article makes the proposition 'universal,' while the English use is not 'particular,' as may appear at first sight, but rather 'generic.'

Now look at this piece of splendid rhetoric:

6. *Le* pinson, *l'*alouette, *la* linotte, *le* serin jasent et babillent tant que le jour dure. *Le* soleil couché, ils fourrent *leur tête* sous *l'*aile, et les[1] voilà endormis. C'est alors que le génie prend *sa* lampe et l'allume,[1] et que l'oiseau solitaire, sauvage, inapprivoisable, brun et triste de plumage, ouvre *son* gosier, et commence son chant, fait retentir le bocage, et rompt mélodieusement le silence et les ténèbres de la nuit.—DIDEROT.	6. The chaffinch, the lark, the linnet, the canary chirp and chatter as long as the day lasts. The sun set, they stuff their head(s) under the wing, and there they are asleep. 'Tis then that the seer takes his lamp and lights it, and that the bird, solitary, wild, untameable, brown and sad of plumage, opens his throat, begins his song, makes the coppice ring, and breaks melodiously the silence and the darkness of the night.

The first thing to notice in this piece is that wherever the definite article is used in English it may be used in French, although you will often find that in French the stronger Demonstrative is preferred. This use is curiously creeping into our sporting press. But there is one important exception. You will notice that in English we can say either *they stuff the head under the wing*, or *their heads under their wings.* In French there is the same liberty; in speaking of parts of the body, when it is quite clear whose body is being referred to—*i.e.* when the possessor is clearly defined—the article is used instead of the possessive, *the* head, tail, legs, instead of *his, her,* head, tail, legs, wings, or what you will. This is brought out in the following passage:

7. En un instant cinquante soldats bondirent dans la cuisine où reposait pacifiquement Walter Schnaffs, et *lui* posant *sur la poitrine* cinquante fusils chargés, le culbutèrent, le lièrent des pieds à la tête. . . . Et tout d'un coup un gros militaire *lui* planta *son pied* sur *le* ventre en vociférant. . . . Il fut relevé, ficelé sur une chaise, et examiné avec une vive curiosité par ses vainqueurs qui soufflaient comme des baleines. Le gros militaire, qui s'essuyait le front, vocifera 'Victoire.' Et il donna l'ordre de repartir. La population anxieuse et surexcitée attendait. Quand on aperçut le casque du prisonnier, des clameurs formidables éclatèrent. Les femmes levaient les bras; des vieilles pleuraient; un aieul lança sa béquille au Prussien et blessa le nez d'un de ses gardiens.—MAUPASSANT.	7. In an instant fifty soldiers bounded into the kitchen where peacefully slept Walter Schnaffs, and placing on his chest fifty loaded rifles, knocked him over, tied him hand and foot. . . . And all at once a big soldier fellow planted his foot on his stomach bellowing. . . . He was picked up, tied to a chair, and examined with a lively curiosity by his victors, who puffed like whales. The big soldier who was wiping his brow bawled out 'Victory.' and (he) gave the order of retreat. The population, anxious and excited, was waiting. When they perceived the helmet of the prisoner, terrific shouts burst out. The women raised their arms; the old ones wept; a patriarch threw his crutch at the Prussian and wounded the nose of one of his guards.

'lui posant sur la poitrine.' The presence of 'lui' makes *his* unnecessary.

'lui planta son pied sur le ventre.' The same is true here. Notice that 'son' refers to the 'militaire.' 'le militaire qui s'essuyait le front'—lit., *the soldier who wiped himself the brow.* The 'se' makes 'son' unnecessary.

'les femmes levaient les bras.' *The arms* is enough, as it is quite clear whose arms they raised. Notice the use of the possessives with 'béquille' and 'gardien.'

Other omissions of the article:

We saw in 'Les Djinns' that the article was omitted in the enumeration of a number of terms, and in apposition. It is also dropped in certain phrases where a noun is closely compounded with a verb, and when with a preposition a noun forms an adverbial phrase. These will be dealt with in their place.

4. **The Partitive Article.**—We have seen that as a rule French insists on the definite article preceding a term which is used generally. So, on the other hand, when a thing is referred to only in part, this also must be signified.

'Du lait!' 'Des violettes!' 'Des poissons!' 'Du saucisson!' 'De la crême!' 'Du vin!' 'De la salade!' 'Des cotelettes!' 'Du pain!' 'De l'eau!' But note that if these cries are preceded by words showing what part or quantity is referred to, then 'du,' 'de la,' 'de l',' 'des' are reduced to 'de' or 'd'' simply. Thus:

'Un pot de lait.' 'Un peu de vin.' 'Un bouquet de violettes.' 'Trop de crême.'

A few literary examples will suffice to illustrate these points.

De grands corps blancs, phlégmatiques, avec *des* yeux bleus farouches, et *des* cheveux d'un blond rougeâtre; des estomacs voraces, répus de viande et de fromage.	Huge white sluggish bodies, with fierce blue eyes, and hair of a reddish blond; voracious stomachs, crammed with meat and cheese.

Thus Taine tabulates the characteristics of our Saxon forefathers.

La fureur de la plupart des Français, c'est d'avoir *de l'esprit*; et la fureur de ceux qui veulent avoir *de l'esprit*, c'est de faire *des* livres.—MONTESQUIEU.	The madness of most of the French is to have 'wit,' and the madness of those who wish to have 'wit' is to make books.

Again, to a lover's eyes:

La noire à faire peur (est)[1] une brune adorable;	The dark 'to distraction' is a brunette adorable;
La maigre a *de la* taille et *de la* liberté. —MOLIÈRE.	The lean one has a form and a freedom in gait.

This use, however, must not be confounded with that of 'de' joined to the article and signifying simply *of the.*

De tous auteurs, il n'y en a point que je méprise plus que les compilateurs qui vont de tous côtés chercher *des* lambeaux *des* ouvrages *des* autres qu'ils plaquent dans les leurs comme *des* pièces de gazon dans un parterre.—MONTESQUIEU.	Of all authors, there is not one that I despise more than the compilers who go all round seeking shreds of the works of others, which they stick into their own as pieces of turf in a lawn.

Here the first 'des' is *some*, the next two *of the*, the last ('des pièces'), *some.*

** 5. **Verbs.**—We saw in the Introductory Chapter that the verb has endings to show

[1] 'les' and 'l'' are not the article *the*, but the pronouns *they* and *it*.

[1] I ask pardon of God and men for intercalating a word in a line of Molière.

tense, number, person, etc., and that verbs go into classes according to the endings they take.

We have already met -*e* as a common Present tense ending for 1st and 3rd persons, and -*ent* as invariably the ending of 3rd plural of the Present tense.

We have also found -*ais*, -*ait*, -*aient* as endings for the Imperfect Past tense.

A glance at Extr. 7 in the last section will show a number of forms of the Past Definite. There we find -*a* replacing the -*e* of 3rd singular Present, and -*irent*, -*erent*, in place of the -*ent* of the 3rd plural.

It is now necessary to study all these forms in full, beginning with the common but irregular verbs 'avoir' and 'être,' *to have* and *to be*.

AVOIR

Indicative — *Subjunctive*

PRESENT

j'ai	*I have*	(que) j'aie
tu as	*thou hast*	tu aies
il a	*he has*	il ait
nous avons	*we have*	nous ayons
vous avez	*you have*	vous ayez
ils ont	*they have*	ils aient

PERFECT (*Past Indefinite*)

j'ai eu	*I have had*	(que) j'aie eu
tu as eu	*thou hast had*	tu aies eu
il a eu	*he has had*	il ait eu
nous avons eu	*we have had*	nous ayons eu
vous avez eu	*you have had*	vous ayez eu
ils ont eu	*they have had*	ils aient eu

PRETERITE (*Past Definite*)

j'eus	*I had*	(que) j'eusse
tu eus	*thou hadst*	tu eusses
il eut	*he had*	il eût
nous eûmes	*we had*	nous eussions
vous eûtes	*you had*	vous eussiez
ils eurent	*they had*	ils eussent

IMPERFECT

j'avais	*I was having*	(que) j'eusse, etc.
tu avais	*thou wast having*	
il avait	*he was having*	
nous avions	*we were having*	
vous aviez	*you were having*	
ils avaient	*they were having*	

PLUPERFECT

j'avais eu	*I had had*	(que) j'eusse eu
tu avais eu	*thou hadst had*	tu eusses eu
il avait eu	*he had had*	il eût eu
nous avions eu	*we had had*	nous eussions eu
vous aviez eu	*you had had*	vous eussiez eu
ils avaient eu	*they had had*	ils eussent eu

FUTURE

j'aurai	*I shall have*
tu auras	*thou wilt have*
il aura	*he will have*
nous aurons	*we shall have*
vous aurez	*you will have*
ils auront	*they will have*

FUTURE PERFECT

j'aurai eu	*I shall have had*
tu auras eu	*thou wilt have had*
il aura eu	*he will have had*
nous aurons eu	*we shall have had*
vous aurez eu	*you will have had*
ils auront eu	*they will have had*

Conditional

PRESENT

j'aurais	*I should have*
tu aurais	*thou wouldst have*
il aurait	*he would have*
nous aurions	*we should have*
vous auriez	*you would have*
ils auraient	*they would have*

PAST

j'aurais eu	*I should have had*
tu aurais eu	*thou wouldst have had*
il aurait eu	*he would have had*
nous aurions eu	*we should have had*
vous auriez eu	*you would have had*
ils auraient eu	*they would have had*

Imperative

PRESENT

aie	*have*
ayons	*let us have*
ayez	*have*

Infinitive

PRESENT		PAST	
avoir	*(to) have*	avoir eu	*(to) have had*

Participles

PRESENT		PAST	
ayant	*having*	eu	*had*
		ayant eu	*having had*

ÊTRE

Indicative — *Subjunctive*

PRESENT

je suis	*I am*	(que) je sois
tu es	*thou art*	tu sois
il est	*he is*	il soit
nous sommes	*we are*	nous soyons
vous êtes	*you are*	vous soyez
ils sont	*they are*	ils soient

PERFECT (*Past Indefinite*)

j'ai été	*I have been*	(que) j'aie été
tu as été	*thou hast been*	tu aies été
il a été	*he has been*	il ait été
nous avons été	*we have been*	nous ayons été
vous avez été	*you have been*	vous ayez été
ils ont été	*they have been*	ils aient été

PRETERITE (*Past Definite*)

je fus	*I was*	(que) je fusse
tu fus	*thou wast*	tu fusses
il fut	*he was*	il fût
nous fûmes	*we were*	nous fussions
vous fûtes	*you were*	vous fussiez
ils furent	*they were*	ils fussent

IMPERFECT

j'étais	*I was*	(que) je fusse, etc.
tu étais	*thou wast*	
il était	*he was*	
nous étions	*we were*	
vous étiez	*you were*	
ils étaient	*they were*	

PLUPERFECT

j'avais été	*I had been*	(que) j'eusse été
tu avais été	*thou hadst been*	tu eusses été
il avait été	*he had been*	il eût été
nous avions été	*we had been*	nous eussions été
nous aviez été	*you had been*	vous eussiez été
ils avaient été	*they had been*	ils eussent été

Future

je serai	*I shall be*
tu seras	*thou wilt be*
il sera	*he will be*
nous serons	*we shall be*
vous serez	*you will be*
ils seront	*they will be*

Future Perfect

j'aurai été	*I shall have been*
tu auras été	*thou wilt have been*
il aura été	*he will have been*
nous aurons été	*we shall have been*
vous aurez été	*you will have been*
ils auront été	*they will have been*

Conditional

Present

je serais	*I should be*
tu serais	*thou wouldst be*
il serait	*he would be*
nous serions	*we should be*
vous seriez	*you would be*
ils seraient	*they would be*

Past

j'aurais été	*I should have been*
tu aurais été	*thou wouldst have been*
il aurait été	*he would have been*
nous aurions été	*we should have been*
vous auriez été	*you would have been*
ils auraient été	*they would have been*

Imperative

Present

sois	*be*
soyons	*let us be*
soyez	*be*

Infinitive

Present		Past	
être	*(to) be*	avoir été	*(to) have been*

Participles

Present		Past	
étant	*being*	été	*been*
		ayant été	*having been*

** 'Avoir' and 'Etre'

It is not possible to find in a short space examples of both the persons and the tenses of 'avoir' and 'être.' As they are the commonest verbs, and as they are also auxiliaries, it has been thought necessary to give an example of their simplest uses in all persons of the main tenses of the Indicative. Apologies are made for the childish nature of the illustration which the limited vocabulary demands.

The example should be compared carefully with the formal conjugation of the verbs on the previous pages.

ACTE I	ACT I
Papa, Maman, Alphonse, Marie	Papa, Mamma, Alphonse, Marie
* Alph. Je suis triste. Mar. Tu es triste? Moi aussi je suis triste. Maman, Alphonse est triste. Mam. Il est triste? Il a froid peut-être. Avez-vous froid, Alphonse? Alph. Non. J'ai mal à la tête. Mam. Alors tu as besoin de la médecine. Mar. Nous avons tous les deux mal. Nous sommes tous les deux malades. Mam. Si vous êtes malades, vous avez tous les deux besoin de la médecine. Pa. Oui, ils ont besoin de la médecine. Ils sont des malades.	Alph. I am sad. Mar. Thou art sad? 'Me' too. I am sad. Mamma, Alphonse is sad. Mam. He is sad? He has cold, perhaps. Have you cold, Alphonse? Alph. No: I have headache. Mam. Then thou hast need of medicine. Mar. We have both 'ill.' We are both sick. Mam. If you are both sick, you have both need of medicine. Pa. Yes, they have need of medicine. They are sick.
Alph. J'*étais* malade. Mar. Nous *étions* malades. Alph. J'*avais* mal à la tête. Mar. Nous *avions* mal. Pa. Tu *étais* malades. Tu *avais* mal à la tête? Alph. Oui, Marie *était* malade. Mar Il *avait* mal à la tête. Mam. C'est bon ça! Ils *étaient* malades. Ils *avaient* mal.	Alph. I *was* sick. Mar. We *were* sick. Alph. I *had* headache. Mar. We *had* 'ill.' Pa. Thou *wast* sick. Thou *hadst* headache. Alph. Yes, Marie *was* sick. Mar. He *had* headache. Mam. That's all very well. They *were* sick. They *had* 'ill.'

ACTE II	ACT II
Alph. Tant pis. Je serai bientôt guéri. Mar. Nous serons contents. Je n'aurai plus mal à la tête. Mar. Nous n'aurons pas besoin de la médecine. Mam. Oui, mais tu *auras* la médecine. Papa! N'est-ce pas qu'ils auront la médecine? Pa. Oui. Ils l'auront, et ils seront guéris. Mes enfants, vous serez guéris.	Alph. Bad luck. I shall be soon cured. Mar. We shall be glad. I shall have no more headache. Mar. We shall have no need of medicine. Mam. Yes, but you *will have* the medicine. Papa, is it not that they will have the medicine? Pa. Yes. They will have it, and they will be cured. My children, you will be cured.

ACTE III	ACT III
Mar. J'ai eu la médecine. Alph. Tu l'as eu? Elle a été très atroce? Mam. Alphonse! Marie a été sage. N'est-ce pas, Marie? Tu as été sage? Mar Oui, j'ai été sage. Mam. Elle a eu la médecine. Alph. *Maintenant* nous l'avons eu. Nous avons été sages. Pa. Vous l'avez eu? Vous avez été sages? Mam. Oui, ils ont été sages, et ils ont eu la médecine. Maintenant au lit.	Mar. I've had the medicine. Alph. Thou hast had it? It has been atrocious? Mam. Alphonse! Marie has been good. Is it not so, Marie? Thou hast been good? Mar. Yes, I have been good. Mam. She has had the medicine. Alph. *Now* we have had it. We have been good. Pa. You have had it? You have been good? Mam. Yes, they have been good, and they have had the medicine. Now to bed.

Note that *thou* is for the most part confined to children and intimates. In the phrases 'Il a froid,' 'J'ai mal,' the French idiom differs from the English. In the latter one is said *to have cold, to have ill*, not *to be cold*, etc. Note also the idiom 'tous les deux,' *both.*

Questions are often asked in French by the inflexion of the voice, as in 'Tu es triste?'

In Act III is illustrated a double use of the Perfect tense, which is also used as a general Past. In English we should say *it was atrocious*, rather than *it has been.*

'N'est-ce pas?' *Is it not?* is a common adjunct to a question in French.

** 6. **The Regular Verbs.**—We have already shown how the verbs arrange themselves in a number of classes (or Conjugations, as they are called), and all verbs in a conjugation take the same endings to show difference of mood, tense, and person.

We see the conjugation which a verb belongs to by looking at its Infinitive. Thus these are types of the chief conjugations:

Conjugation I. Chanter, *to sing.*
II. Finir, *to finish.*
IV. Rompre, *to break.*

while there are besides two small conjugations, types of which are:

III. Recevoir, *to receive.*
IIb. Dormir, *to sleep.*

The 'recevoir' class is an awkward little conjugation of six verbs, and the 'dormir' class is really a variant of the 'finir' conjugation.

To show how these verbs agree and differ, we will give what are called their Principal Parts. They are the Infinitive, the Present tense of the Indicative, the Past Definite tense (Indicative), the Present and Past Participles. These are:

INFINITIVE.	PRES. INDIC.	PAST DEF.	PRES. PART.	PAST PART.
chanter	chante	chantai	chantant	chanté
finir	finis	finis	finissant	fini
rompre	romps	rompis	rompant	rompu
recevoir	reçois	reçus	recevant	reçu
dormir	dors	dormis	dormant	dormi

It is only in the Present and Past Definite tenses that we find really distinctive forms in each conjugation, and even then the plurals closely resemble one another, while all but the *-er* conjugation end in the singular in *-s*, *-s*, *-t*.

The Imperfect tense has the same endings in all verbs, but the question of conjugation comes in in the stem. This can always be obtained by taking the stem of the Present Participle and substituting for the termination *-ant* the following: *-ais*, *-ais*, *-ait*, *-ions*, *-iez*, *-aient*. So also the Future and the Conditional tack their endings on to the stem of the Infinitive (in some cases slightly abbreviated; see 'rompre' and 'recevoir').

TYPES OF CONJUGATIONS

PRESENT TENSE

je	tu	il	nous	vous	ils	
chante	chantes	chante	chantons	chantez	chantent	*sing.*[1]
finis	finis	finit	finissons	finissez	finissent	*finish.*
romps	romps	rompt	rompons	rompez	rompent	*break.*

Six verbs follow 'recevoir,' and seven 'dormir.'

reçois	reçois	reçoit	recevons	recevez	reçoivent	*receive.*
dors	dors	dort	dormons	dormez	dorment	*sleep.*

THE PAST DEFINITE

je	tu	il	nous	vous	ils	
chantai	chantas	chanta	chantâmes	chantâtes	chantèrent	*sang.*
finis	finis	finit	finîmes	finîtes	finirent	*finished.*
rompis	rompis	rompit	rompîmes	rompîtes	rompirent	*broke.*
reçus	reçus	reçut	reçûmes	reçûtes	reçurent	*received.*
dormis	dormis	dormit	dormîmes	dormîtes	dormirent	*slept.*

THE IMPERFECT.—*I was singing, etc.*

To show how the stem is that of the Present Participle, we place it at the head:

	je	tu	il
chantant	chantais	chantais	chantait
finissant	*finiss*-ais	finiss-ais	finiss-ait
rompant	rompais	rompais	rompait
recevant	*recev*ais	recevais	recevait
dormant	dormais	dormais	dormait

nous	vous	ils
chantions	chantiez	chantaient
finissions	finissiez	finiss-aient
rompions	rompiez	rompaient
recevions	receviez	recevaient
dormions	dormiez	dormaient

[1] To obtain the English in full for a tense of any verb, substitute that verb for 'have' in the conjugation of the latter verb (p. 245).

THE FUTURE.—*I shall sing, etc.*

Here the stem, it will be seen, is that of the Infinitive:

	je	tu	il
chanter	chanterai	chanteras	chantera
finir	finirai	finiras	finira
rompr'	romprai	rompras	rompra
recev'r	recevrai	recevras	recevra
dormir	dormirai	dormiras	dormira

nous	vous	ils
chanterons	chanterez	chanteront
finirons	finirez	finiront
romprons	romprez	rompront
recevrons	recevrez	recevront
dormirons	dormirez	dormiront

THE CONDITIONAL.—*I should sing, etc.*

To the same stem as the Future add the Imperfect endings:

chanterais	chanterais	chanterait
finirais	finirais	finirait
romprais	romprais	romprait
recevrais	recevrais	recevrait
chanterions	chanteriez	chanteraient
finirions	finiriez	finiraient
romprions	rompriez	rompraient
recevrions	recevriez	recevraient

The compound tenses may be considered apart from the question of conjugation, for as they are formed by joining an auxiliary verb to the Past Participle, the only evidence of difference in conjugation is in the differing forms of the Past Participles.

The Perfect or Past Indefinite is formed by joining the Present tense of 'avoir' to the Past Participle:[1]

j'ai	chanté	nous avons	chanté
tu as	fini, reçu	vous avez	fini, reçu
il a	rompu, dormi	ils ont	rompu, dormi

I have sung, finished, broken; or, I sang, finished, broke, etc.

This tense, as has been said, does double duty. It corresponds to the English Perfect, and it also serves as a general Past tense.

The Pluperfect is formed by joining the Imperfect tense of 'avoir' to the Past Participle:

j'avais	chanté	nous avions	chanté
tu avais	fini, reçu	vous aviez	fini, reçu
il avait	rompu, dormi	ils avaient	rompu, dromi

I had sung, finished, broken, etc.

The Future Perfect joins the Future of 'avoir' to the Past Participle:

j'aurai	chanté	nous aurons	chanté
tu auras	fini, reçu	vous aurez	fini, reçu
il aura	rompu, dormi	ils auront	rompu, dormi

I shall have sung, finished, broken, etc.

The Past Conditional joins the Conditional Present of 'avoir' to the Past Participle:

j'aurais	chanté	nous aurions	chanté
tu aurais	fini, reçu	vous auriez	fini, reçu
il aurait	rompu, dormi	ils auraient	rompu, dormi

I should have sung, finished, broken, etc.

[1] With verbs of motion, and reflexive verbs, 'être' is used instead of 'avoir.'

The Imperative Mood

The Imperative is formed as a rule from the Present Indicative, the pronouns being dropped:

[1] chante	*sing*	chantons	*let us sing*	chantez	*sing*
[1] finis	*finish*	finissons	*let us finish*	finissez	*finish*
[1] romps	*break*	rompons	*let us break*	rompez	*break*
So—reçois		recevons		recevez	
dors		dormons		dormez	

I keep the Subjunctive till later, when its use is fully explained.

Notes on Some Verbs of the First Conjugation

Verbs like 'jeter,' *to throw*, 'appeler,' *to call*, 'mener,' *to lead*, have a mute *e* in the stem; and when this is followed by another mute *e*, to avoid an awkward sound, the first *e* mute becomes grave, or achieves the same result by doubling the following consonant. This change operates in the 1st, 2nd, and 3rd singular and 3rd plural of the Present Indicative, and throughout the Future and Conditional. Examples:

je mène, tu mènes, il mène, ils mènent, je mènerai, je mènerais

When the final consonant is *l* or *t*, it is generally doubled, but there are exceptions. Thus:

je jette	tu jettes	il jette	ils jettent
but—j'achète	tu achètes	il achète	ils achètent

and 'geler,' *to freeze*, 'peler,' *to peel*, 'celer,' *to conceal*, go likewise.

In the same way verbs which have an *é* in the last syllable of the stem convert this *é* into an *è*.

j'espère, etc. j'espèrerai, etc. j'espèrerais, etc.

Again, as *g* and *c* are pronounced hard before *a*, *o*, and *u*, to preserve the soft sound which they have in the Infinitive, *g* inserts an *e* after it, and *c* takes a sign known as the cedilla, before terminations beginning with those vowels. Thus in the Present Indicative we have 'nous mangeons,' and in the Imperfect:

je mangeais	tu mangeais	il mangeait	ils mangeaient
j'avançais	tu avançais	il avançait	ils avançaient

When *y* is followed by an *e* mute it becomes *i*. Thus in the Present Indicative 'employer' becomes:

j'emploie, tu emploies, il emploie (nous employons, vous employez), ils emploient. *Future*, j'emploierai, etc. *Conditional*, j'emploierais, etc.

Note, however, that verbs in 'ayer,' 'eyer,' usually retain the *y*.

There are two verbs in the 1st conjugation with further irregularity. 'Envoyer,' besides losing its *y* in the cases indicated for 'employer,' has an irregular Future—'Enverrai,' etc. 'Aller,' *to go*, introduces other forms in the Present Indicative, which are:

je vais	nous allons
tu vas	vous allez
il va	ils *vont*

and the Future, which is:

j'irai, etc. [*Conditional*, j'irais.]

[1] This form is used in the intimate style only.

The Present Subjunctive is also irregular.

Que j'aille	Que nous allions
,, tu ailles	,, vous alliez
,, il aille	,, ils aillent

Rule of the Principal Parts

It will be noticed, typically with 'finir,' 'dormir,' 'recevoir,' that there is a certain amount of change in stem in conjugation.

Thus 'finir,' but Present Participle 'finissant.' 'Dormir,' Present Indicative 'je dors,' Present Participle 'dormant.' 'Recevoir,' but Present Indicative singular 'reçois,' Past Definite 'reçus.'

None the less verb-forms group themselves under heads, and even in irregular verbs they only fail to do so when euphony causes a change. The commonly recognised heads are:

The Infin., which gives the stem of the Future and Conditional.	The Pres. Indic. Sing., which stands alone.	The Pres. Part., which gives the Imperfect and the plural of the Pres. Indic.
The Past Definite, which gives the Imperfect Subjunctive.		The Past Participle, which gives the compound tenses.

Examples—

Finir	Finis	Finissant	Finis	Fini
Fut. Finirai	Finis	*Imp.* finissais.	*Imp. Sub.*	j'ai fini,
Con. Finirais	Finit	*Pres. Indic.*	Finisse	etc.
		Plur. Finissons, etc.		

[Note that the Imperative is not formed from the Present Indicative, but *is* the Present Indicative in certain persons, without the pronouns (except 'savoir').]

The more the learner studies this arrangement, the more will he find the way through irregular verbs simpler.

EXAMPLES OF TENSES

The Indicative

Third Singular Present Tense

L'Hirondelle	The Swallow
Ainsi elle *mange* en volant, elle *boit*,[1] *se baigne* * en volant, en volant elle *nourrit* ses petits. Elle *tourne*, elle *fait*[1] cent cercles, un labyrinthe de courbes qu'elle *croise*, *recroise* à l'infini. L'ennemi s'y *ébloult*, s'y *perd* s'y *brouille*, et ne sait plus que faire. Elle le *lasse*, l'*inquiète*; il *renonce* et la laisse non fatiguée.	Thus she eats in flight, she drinks, she bathes in flight, while flying she feeds her young. She turns, she makes a hundred circles, a labyrinth of curves, which she crosses and recrosses to infinity. The foe dazzles, loses and muddles himself in it, and knows not what to do. She tires him, harasses him; he gives up and leaves her unfatigued.

Then, addressing 'l'hirondelle' in that 2nd person singular, known to us principally in the commandments, but in French employed 'en famille' and to little ones, the author continues:

Qui donc *es-tu*, toi qui te *dérobes* toujours, qui ne *laisses* voir que tes ailes tranchantes. . . . Tu' m'*approches*, tu me *rases*, tu voudrais me toucher. Tu me *caresses* de si près, que j'*ai* au visage le vent de ton aile.	Who, then, art thou, who escapeth always, who showeth only thy cleaving wings. . . . Thou approachest me, thou grazest me, thou wouldst touch me. Thou caressest me so closely that I have in my face the wind of thy wing.

[1] Irregular.

In this 'morceau' we have a very varied choice of all the persons of the Present tense :

* Je vais, Clitophon, à votre porte ; le besoin que j'ai de vous me *chasse* de mon lit et de ma chambre. Vos esclaves me *disent* [1] que vous êtes enfermé, et que vous ne *pouvez* m'ecouter que d'une heure entière. Je *reviens* [1] . . et ils me *disent* que vous êtes sorti. Que *faites* [1] vous, Clitophon ? Vous *enfilez* quelques memoires, vous *collationnez* un registre, vous *signez*, vous *paraphrasez ;* je n'*avais* qu'une chose à vous demander, et vous n'*aviez* qu'une chose à me répondre, oui ou non. O homme important et chargé d'affaires, qui, à votre tour, *avez* besoin de mes offices, *venez* dans la solitude de mon cabinet. Je ne vous *remettrai* point à un autre jour. Vous me *trouverez* sur les livres de Platon qui *traitent* de la spiritualité de l'âme.—La Bruyère.	I go, Clitophon, to thy door ; the need I have of you drives me from my bed and from my room. Your slaves tell me that you are shut up, and that you cannot hear me for a whole hour. I return . . . and they tell me that you are gone out. What are you doing, Clitophon ? You are filling some memoirs, you collate a register, you sign, you paraphrase ; I had but one thing to ask you, and you had but one thing to answer me, yes or no. O man important and loaded with business, who in your turn have need of my help, come into the solitude of my study. I will not put you off to another day. You will find me at my leave books of Plato which treat of the immortality of the soul.
J'*admire* Dieu dans ses ouvrages, et je *cherche* par la connaissance de la verité à regler mon esprit et à devenir meilleur.	I admire God in His works, and I seek by the knowledge of truth to rule my spirit and to become better.
Reproches d'un Gentilhomme à Son Fils	Reproaches of a Nobleman to his Son
* Ne *rougissez*-vous point de mériter si peu de votre naissance ? *Etes*-vous en droit, *dites* moi, d'en tirer quelque vanité ? Et qu'*avez*-vous fait dans le monde pour être gentilhomme ? *Croyez*-vous qu'il *suffise* d'en porter les armes et le nom ? et que ce nous *soit* une gloire d'être sortis d'un sang noble, lorsque *nous* vivons en infame ? Non, non, la naissance n'*est* rien où la vertu ne l'est pas. Nous n'*avons* part à la gloire de nos ancêtres qu'autant que nous nous efforçons de leur ressembler ; et cet éclat qu'ils *repandent* sur nous, nous *impose* un engagement de suivre les pas qu'ils *tracent*. *Apprenez* [1] enfin qu'un gentilhomme qui *vit* [1] mal est un monstre de la nature ; que je *regarde* bien moins au nom qu'on signe qu'aux actions qu'on fait ; et que je ferais [1] plus d'état du fils d'un crocheteur qui serait honnête homme, que du fils d'un monarque qui vivrait comme vous.	Do you not blush to merit so little from your birth ? Are you in the right, tell me, to get from it vanity ? And what have you done in the world to be noble ? Do you believe that it is enough to bear the arms and the name, and that it is a glory to us to issue from a noble line when we live in infamy ? No, birth is nothing where virtue is not. We have no part in the glory of our ancestors but in so far as we force ourselves to resemble them ; and that splendour which they cast on us imposes on us a need to follow the steps they trace. Learn, in fine, that a nobleman who lives is a monster ; that I look a good deal less at the name one signs than at the actions one does ; and that I should make more of the son of a cobbler who was an honest man, than of the son of a monarch who lives like you.

The Present Historic

Fragment from one of the 'Oraisons funèbres' for which Bossuet was so justly famous :

Madame se meurt.[1] Madame est morte. Qui de nous ne se sentit frappé à ce coup ? Au premier bruit d'un mal si étrange, on *accourt* à Saint-Cloud de toutes parts. On *trouve* tout consterné, excepté le cœur de cette princesse. Partout on *entend* des cris ; partout on *voit* la douleur et le désespoir, et l'image de la mort. Le roi, la reine, Monsieur, toute la cour, tout le peuple, tout *est* abattu, tout *est* désesperé ; et il me *semble* que je *vois* l'accomplissement de cette parole du prophète. . . .	Madame is dying. Madame is dead. Who of us did not feel struck by this blow ? At the first rumour of so strange an ill, we rush to St. Cloud from all parts. We find all panic-stricken except the heart of that princess. Everywhere one hears cries ; everywhere one sees grief and despair, and the image of death. The King, the Queen, Monsieur, all the court, all the people, all overwhelmed, all in despair ; and it seems to me that I see the accomplishment of that saying of the prophet.

Another deathbed—that of Turenne, the opponent of Marlborough :

Je me trouble, messieurs. Turenne *meurt*. Tout se *confond :* la fortune *chancelle*, la victoire se *lasse*, la paix *s'éloigne*, les bonnes intentions des alliés se *ralentissent*, les courage des troupes est abattu par la douleur et ranimé par la vengeance. Tout le camp *demeure* immobile. Les blessés *pensent* à la perte qu'ils ont faite, et non aux blessures qu'ils ont reçues. Les pères mourants *envoient* leurs fils pleurer sur leur général mort.	I am troubled, sirs. Turenne is dying. All is in confusion : fortune reels, victory halts, peace recedes, the good intentions of the allies gives way, the courage of the troops is overwhelmed by grief and revived by vengeance. All the camp remains motionless. The wounded think of the loss they have sustained, and not of the wounds they have received. Fathers dying send their sons to weep over their dead general.

The Future

Invitation from Voltaire to one of Corneille's descendants to come and live with him :

* Nous passons plusieurs mois de l'année dans une campagne auprès de Genève ; mais vous y *aurez* toutes les facilités pour tous les devoirs de votre religion. Notre principale habitation est en France, dans un château très logeable où vous *serez* beaucoup plus commodement qu'ici. Vous *trouverez* dans l'une et dans l'autre habitation de quoi vous occuper, tant aux petits ouvrages de la main qu *pourront* [1] vous plaire, qu'à la musique et la lecture. Nous *ferons* [1] venir un maître qui *sera* très honoré d'enseigner quelque chose à la petite-fille du grand Corneille ; mais je le *serai* beaucoup plus de lui de vous voir habiter chez moi.	We pass several months of the year in an estate near Geneva ; but you will have there all facilities for all the duties of your religion. Our chief dwelling is in France, in a very habitable chateau where you will be much more at your ease than here. You will find in the one and the other dwelling something to occupy you as much as in the little handiworks which will be able to occupy you as in music and reading. We will make a master come who will be very honoured to teach something to the grand-daughter of the great Corneille ; but I shall be much more so to see you dwelling with me.

The Imperfect and the Past Definite

A Night in the Open Air

* Des jardins élèvés en terrasse *bordaient* la route. Il avait fait très chaud ce jour-là, la soirée *était* charmante, la rosée *humectait* l'herbe flétrie ; point de vent, une nuit tranquille ; l'air *était* frais sans être froid ; le soleil après son coucher avait laissé dans le ciel des vapeurs rouges dont la réflexion *rendait* l'eau couleur de rose. Les arbres *étaient* chargés de rossignols qui se *répondaient* l'un à l'autre. Je me *promenais* dans une sorte d'extase, livrant mes sens et mon cœur à la jouissance de tout cela. Absorbé dans ma douce rêverie, je *prolongeai* fort avant dans la nuit ma promenade, sans m'apercevoir que *j'étais* las Je m'en *aperçus* enfin. Je me *couchai* voluptueusement sur la tablette d'une espèce de niche enfoncée dans un mur de terrasse ; le ciel de mon lit *était* formé par les arbres ; un rossignol *était* précisement au-dessus de moi ; je m'endormis à son chant ; mon sommeil fut doux, mon	Gardens raised in terraces bordered the road. It had been very hot that day, the evening was charming, the dew moistened the withered grass ; no wind, a peaceful night ; the air was fresh without being cool ; the sun after its setting had left in the sky red vapours whose reflection made the water rose-coloured. The trees were loaded with nightingales, who answered one another. I walked in a sort of ecstasy, delivering my senses and my heart to the enjoyment of all this. Absorbed in my sweet reverie, I prolonged my walk well on into the night without perceiving that I was tired. I noticed it at length. I lay down with delight on the flat of a kind of niche hollowed out in a terrace wall ; the canopy of my bed was formed by the trees ; a nightingale was just above me ; I went to sleep to his song ; my sleep was sweet, my dreaming more so. . . . It was full day ; my

1 Irregular.

rêve le *fut* d'avantage. . . . Il *était* grand jour ; mes yeux en s'ouvrant *virent* [1] le ciel, le soleil, l'eau, la verdure—un paysage admirable. Je me *levai*, me *secouai* ; la faim me *prit* ; j'acheminai gaiement vers la ville.—ROUSSEAU.

eyes on opening saw the sky, the sun, the water, the verdure —a lovely landscape; I rose and shook myself; hunger took hold on me; I took the road gaily towards the town.

This extract, taken from early French history, also offers an excellent study of the use of the Past Definite tense. Notice how the Imperfect comes in from time to time, when not a definite act is related, but a state or condition. (Irregular verbs are referred, when necessary, to the list where they are conjugated.)

* Une longue file de cavaliers, de voitures, et de chariots de bagage *traversa* les rues de Tolède, et se *dirigea* vers la porte du Nord. Le roi *suivit* à cheval le cortège de sa fille jusqu'au pont jeté sur le Tage ; mais la reine ne *put* [1] se résoudre à retourner si vite, et *voulut* aller au delà. Quittant son propre char, elle *s'assit* [1] auprès de Galeswinthe, et, d'étape en étape, de journée en journée, elle se *laissa* entraîner à plus de cent milles de distance. À l'approche des montagnes, les chemins *devinrent* [1] difficiles ; elle ne s'en *aperçut* pas, et *voulut* aller plus loin. Mais comme les gens qui la *suivaient*, grossissant beaucoup la cortège, *augmentaient* les embarras et les dangers du voyage, les seigneurs goths *résolurent* [1] de ne pas permettre que leur reine *fît* un pas de plus. Il *fallut* [1] se résigner à une separation inévitable, et nouvelles scènes de tendresse *eurent* lieu entre la mère et la fille. . . . Avant de monter sur le char qui devait la ramener en arrière, la reine des Goths s'arrêta au bord de la route, et, fixant ses yeux vers le chariot de sa fille, elle ne *cessa* de la regarder jusqu'à ce qu'il *disparut* [1] dans l'éloignement.

A long line of horsemen, of carriages, and carts traversed the streets of Toledo, and made for the North Gate. The king followed the train of his daughter on horseback as far as the bridge thrown across the Tagus; but the queen could not resolve to return so quickly, and wished to go beyond. Leaving her own car, she seated herself by Galeswinthe, and, from stage to stage, from day to day, she let herself be carried more than a hundred miles' distance. At the approach of the mountains, the roads became more difficult; she did not perceive it, and wished to go farther. But as the people who followed her increased considerably the train, and added to the difficulties and dangers of the journey, the Gothic lords resolved not to permit that their queen should go another step. It was necessary to resign oneself to an inevitable separation, and new scenes of tenderness took place between the mother and daughter. . . . Before mounting the car which was to take her back, the queen of the Goths stopped beside the road, and, fixing her eyes on her daughter's car, she did not cease looking at it till it disappeared in the distance.

The Past Indefinite (and Perfect)

* Le propriétaire du château n'*a pensé* qu'à en sortir. Enfermé là quand il le fallait absolument pour sa sûreté ou son indépendance, il *est allé*, aussi souvent qu'il l'*a pu*, chercher au dehors ce qui lui manquait—la société, l'activité. La vie des possesseurs de fiefs s'*est passée* sur les grands chemins, dans les aventures. Cette longue série de courses, de pillages, de guerres, qui caractérise le moyen âge, *a été*, en grand partie, l'effet du genre de l'habitation féodale. . . . Ils *ont cherché* partout le mouvement social qu'ils ne trouvaient pas dans leur intérieur.

The owner of the castle only thought of getting out of it. Shut up there when it was quite necessary for his safety or his independence, he went as often as he could to seek outside that which he wanted—society and activity. The life of the possessors of the great fiefs was passed on the high roads, in adventures. This long series of hunts, pillages, and wars, which characterises the Middle Ages, was, in great part, the effect of the feudal dwelling. . . . They sought everywhere the bustle of society which they did not find at home.

Note in this passage that the Compound tense would be translated in English not by the Perfect, but by the simple Past :

The proprietor of the castle only *thought* . . . he *went* as often as he *could* . . . Life *passed* . . . This long series of expeditions *was* for the most part . . . They *sought* . . .

This brings home the fact that this tense in French is the general Past tense as well as the Perfect. Correspondingly in English the tense of *thought*, *went*, etc., is both the Past Definite and Indefinite.

Milords, je suis née reine, princesse souveraine et non sujette aux lois, proche parente de la reine d'Angleterre et sa légitime héritière. Après *avoir été* longuement et injustement détenue prisonnière en ce pays, où *j'ai* beaucoup *enduré* de peine et de mal, sans qu'on eût aucun droit sur moi, maintenant par la force et sous la puissance des hommes, prête à finir ma vie, je remercie mon Dieu d'*avoir permis* que je meure pour ma religion et devant une compagnie qui sera témoin que, bien près de ma mort, *j'ai protesté* comme je l'*ai* toujours *fait*, soit en particulier, soit en public, de n'*avoir* jamais rien *inventé* pour faire périr la reine, ni *consenti* à rien contre sa personne.—MARY QUEEN OF SCOTS.

My lords, I was born queen, a sovereign princess and not subject to the laws, a near parent of the Queen of England and her legitimate heir. After having been long and unjustly detained prisoner in this country, where I have endured much pain and ill, without their having any rights over me, now—by the force and under the power of men, (being) ready to finish my life —I thank God for having permitted that I die for my religion and before a company which will be witness that, near death, I have protested, as I have always done, whether in public or private, of never having ever invented anything to kill the Queen, nor consented to anything against her person.

In this extract the Compound Past tense (italicised) is the genuine Perfect. Note 'avoir été,' 'avoir permis,' the Perfect Infinitive.

The Conditional

This tense, or mood, as it may be also regarded, for it has two forms, a Past as well as a Present, needs some attention. It has two uses, both of which correspond more or less to the occasions on which we in English use the auxiliaries *should* or *would* ; but in French the use is far more defined, and where we would use either the Indicative simply or the *should* or *would*, in French the Conditional is obligatory. But here are some examples :

Si nous rêvions toutes les nuits la même chose, elle nous affecterait peut-être autant que les objets que nous voyons tous les jours. Si nous rêvions toutes les nuits que nous sommes poursuivis par des ennemis, et agités par des fantômes pénibles, on souffrirait presque autant que si cela était véritable.—PASCAL.

If we dreamed the same thing every night, it would affect us perhaps as much as the objects which we see every day. If we dreamed every night that we were pursued by enemies and harassed by gruesome phantoms, one would suffer almost as much as if it were true.

Si on avait pu, on aurait mis la force entre les mains de la justice.—*Id.*

If one had been able, one would have put force into the hands of justice.

Si le nez de Cléopâtre eût été plus court, tout la face de la terre aurait été changé.—*Id.*

If the nose of Cleopatra had been shorter, all the face of the world would have been changed.

Si les médicins avaient le vrai art de guérir, ils n'auraient que faire de bonnets carrés : la majesté de ces sciences serait assez véritable d'elle-même.—*Id.*

If doctors had the real art of healing, they would have nothing to do with square caps: the majesty of the knowledge would be true enough of itself.

Pour moi, j'aimerais mieux être obligé de commander une armée, que d'écrire ces terribles lignes non finies ; j'aurais la chance d'avoir un imbécile pour ennemi ; mes généraux me remplacerait : mais trouver six beaux vers !—TAINE.

For my part, I should prefer to be forced to command an army than to write those terrible unfinished lines (*i.e.* verse): I would have the chance of having a fool for an enemy : my generals would take my place ; but to make up six good stanzas !

[1] These verbs, being irregular in the form employed here, must be sought in their place in the irregular verbs.

We can very clearly deduce from these examples this rule: that the Conditional is used in connection with 'si'; but a closer observation will show us that it is not used in the same clause as 'si,' but in the opposing one—the apodosis, or following one, as it is called. This is the general rule.

In the example about the nose of Cleopatra, two constructions are mixed—Pascal was rather given this way. When the Subjunctive is used, it is supposed that the condition is very unlikely, and then the verb in both clauses is in the Subjunctive. (For examples see the Subjunctive.)

Note in the Present tense 'si' is found with not the Conditional but the Present in the following clause, and in defiance of grammarians some writers do this with the Future.

If we examine the verbs in this passage we shall find—the tares with the wheat—numerous examples of irregularities in conjugation:

* THE SAVANT AND THE PREHISTORIC SKULL

	Voici la dent d'un homme qui *vécut* au temps du mammouth, pendant les âges de glaces, dans une caverne jadis nue et desolée. . . . Cet homme ne *connaissait* que la peur et la faim . . . telle fut
Passé Déf.	la première humanité. Mais insensiblement, par de longs et magnifiques efforts, les hommes, devenus moins misérables, *devinrent* moins féroces . . . la face humaine *prit* une beauté suprême et le sourire *naquit* sur les
Prés.	lèvres de la femme. . . . Vieil homme. . . . reçois l'hommage de ma reconnaissance, car je *sens* combien je te *dois*. Je *sais* ce que tes efforts m'ont épargné de misères.
Passé Déf.	Tu ne pensais point à l'avenir, il est vrai . . . tu ne *pus* guère songer qu'à te nourrir et te cacher . . . tu *vécus* misérable; tu ne vécus pas en vain, et la vie que tu avais reçue si affreuse, tu la *transmis* un peu moins mauvais à tes enfants. Ils travaillèrent à
Passé Indéf.	leur tour. . . . Tous, ils *ont mis* la main aux arts. . . . Ils se sont tous ingeniés, et l'effort continue de tant d'esprits à travers les âges a *produit* des merveilles qui maintenant embellissent la vie.
Impf.	Et chaque fois qu'ils fondaient une art ou inventaient une industrie ils *faisaient* naître . . . des beautés morales et
P.D.	créaient des vertus. Ils donnèrent des voiles à la femme, et les hommes *connurent* le prix de la
Prés.	beauté. . . . Ainsi nous leur devons tout à ces ancêtres, tout et même l'amour.—ANATOLE FRANCE.

Here is the tooth of a man who lived at the time of the mammoth, during the ages of ice, in a cavern long bare and desolate. . . . This man knew only fear and hunger . . . such was the first humanity. But insensibly, by long and magnificent efforts, men having become less miserable, because less wild . . . the human face took on a supreme beauty, and the smile was born on the lips of woman. . . . Ancient man . . . receive the homage of my gratitude, for I feel how much I owe you. I know what your efforts have spared me of misery. You did not think of the future, it is true . . . you could hardly think but of feeding and hiding yourself . . . you lived wretchedly; you did not live in vain, and life that you received so rightful, you passed (it) on to your children a little less evil. They laboured in their turn. All put their hand to the arts. All contrived, and the effort, continued by so many minds through the ages, has produced the marvels which now adorn life. And each time that they founded an art or invented an industry they made moral beauties appear and created virtues. They gave to woman her robes, and men learned the price of beauty. . . . Thus we owe them all, these ancestors—all, even love.

When we examine the verbs in this piece, we readily recognise the following:

INFINITIVE. 'Songer,' 'nourrir,' 'cacher.'
IMPERFECT. 'Inventaient,' 'créaient,' 'fondaient,' 'pensais.'
PRESENT. 'Reçois,' 'sens,' 'embellissent,' 'devons.' 'Devons' belongs to the 'recevoir' class, while 'embellissent' follows 'finissent' (INFINITIVE 'embellir,' like 'finir'), and 'sens' is of the 'dormir' class (INFINITIVE 'sentir,' as 'dormir').
PAST DEFINITIVE. 'Travaillèrent' and 'donnèrent' are obviously of the 'chanter' class.
TENSES COMPOUNDED WITH PARTICIPLES. 'Ont épargnés' and 'sont ingeniés' follow 'chanter'—so also 'desolée'—while 'avais reçu,' is a part of 'recevoir.'

But there are quite a number of verbs which leave us in the dark. Even to look up a verb we must know its Infinitive stem; and it is just in the stem that we suspect these specimens:—

IMPERFECT	PAST DEFINITE		PAST PART.	
connaissait	[vécut]	devinrent	mis	'Sais,' we see,
	prit	connurent	produit	is Present by the
	pus		devenu	sense.
	transmis			
	[naquit]			

[Vécut and naquit are anomalies rather than irregularities.]

Change of stem, then, is the main source of irregularity, as we have already seen in the case of 'recevoir' and 'dormir.'

'Recevoir.' Present Indicative 'reçois'; plural 'recevons'; Past Definite 'reçus.'
'Dormir.' Present Indicative 'dors'; plural 'dormons'; Present Participle 'dormant,' not 'dormissant.'

But irregular verbs usually obey the Principal Part Rule (page 248). If they do not, then a new source of irregularity arises. So it is a saving of time to know the principal parts of irregular verbs, as we shall then see what is to be memorised and what may be inferred. We give it for these verbs:

INFINITIVE.	PRES. SING.	PRES. PART.	PAST DEF.	PAST PART.
connaître	connais	connaissant	connus	connu
faire	fais	fais-ant	fis	fait
prendre	prends	prenant	pris	pris
pouvoir	peux	pouvant	pus	pu
de-venir	-viens	-venant	-vins	-venu
produire	produis	produisant	produisis	produit
savoir	sais	[savant]	sus	su
trans-mettre	mets	mettant	mis	mis

We can see from these examples how a verb is irregular. 'Connaître' changes its stem in the Past Definite and Past Participle. The plural of the Present Indicative is 'connaiSSons,' etc., following the Present Participle 'ConnaiSSant.' It also inserts a circumflex where *s* is wanting.

'Faire' has an irregular Past Definite and Past Participle, and adds *-s* to the stem *fai-*. Its Future is 'ferai,' not 'fairai,' which is a breach of the Principal Part Rule.

'Pouvoir' is highly irregular, though it follows 'recevoir' in the main. Its Future is irregular ('pouvrai' has naturally become 'pourrai').

'De-venir' has an irregular Future, 'deviendrai,' and 'viens' is also the stem of the Present Indicative singular. Its Past Participle is also irregular—'venu,' not 'veni.'

'Produire,' like 'faire,' introduces an *-s* at

the end of its stem. It also has a Past Participle ending in *-t*—a common irregularity.

'Savoir' does its best to follow 'recevoir,' but has an irregular Future ('savrai' has become 'saurai').

'Transmettre' loses one *-t* in the Present Indicative singular, and changes the stem in the Past Definite and Past Participle.

** 7. **Irregular Verbs.**—We now give a list of irregular verbs with the tenses arranged under the heads of the so-called Principal Parts. We will first take the commonest verbs and those the forms of which will be most difficult to recognise. The Conditional will not be given, as its stem is always the same as that of the Future. Note that the plural of the Present Indicative is ranged under the head of the Present Participle, but that in the 3rd person it often goes back to the singular stem. The Imperfect follows the Present Participle in its stem in every case but one ('savoir'), and the Imperfect Subjunctive invariably forms its stem as does the Past Definite. We give the Past Participle with the auxiliary forming the Past Indefinite, as that auxiliary is sometimes 'avoir,' sometimes 'être.'

For 'aller' and 'envoyer,' see notes to the conjugation in *-er*.

INFINITIVE	PRES. IND. SING.	PRES. PART.	PAST DEF.	PAST PART.
courir, *to run*		*courant*	*courus*	J'ai *couru*
Fut. *courrai*		Imp. *courais*		
	cours	Plur. courons		
	cours	courez		
	court	courent	courusse	
Present Subjunctive	coure, coures, coure, courions, couriez, courent.			
mourir, *to die*		*mourant*	*mourus*	Je suis *mort*
Fut. *mourrai*		Imp. mourais		
	meurs	mourons		
	meurs	mourez		
	meurt	*meurent*	mourusse	
tenir, *to hold*		*tenant*	*tins*	J'ai *tenu*
Fut. *tiendrai*		Imp. tenais		
	tiens	tenons		
	tiens	tenez		
	tient	*tiennent*	tinsse	
Present Subjunctive	tienne, tiennes, tienne, tenions, teniez, tiennent. So 'venir,' but 'je suis venu.'			
pouvoir, *to be able*		*pouvant*	*pus*	J'ai *pu*
Fut. *pourrai*		Imp. pouvais		
	peux	pouvons		
	peux	pouvez		
	peut	*peuvent*	pusse	
Present Subjunctive	puisse, puisses, puisse, puissions, puissiez, puissent.			
savoir, *to know*		*savant* [1] *sachant*	*sus*	J'ai *su*
Fut. *saurai*		Imp. *savais*		Note. Imperative, *sache*,
	sais	*savons*		*sachons*,
	sais	*savez*		*sachez*.
	sait	*savent*	susse	
Present Subjunctive	sache, saches, sache, sachions, sachiez, sachent.			
voir, *to see*		*voyant*	*vis*	J'ai *vu*
Fut. *verrai*		Imp. voy-ais		
	vois	voyons		
	vois	voyez		
	voit	*voient*	visse	

[1] This form is only used as an adjective.

INFINITIVE	PRES. IND. SING.	PRES. PART.	PAST DEF.	PAST PART.
vouloir, *to will*		*voulant*	*voulus*	J'ai *voulu*
Fut. *voudrai*		Imp. voulais		
	veux	voulons		
	veux	voulez		
	veut	*veulent*	voulusse	
Present Subjunctive	veuille, veuilles, veuille, voulions, vouliez, veuillent.			
boire, *to drink*		*buvant*	*bus*	J'ai *bu*
Fut. boirai		Imp. buvais		
	bois	buvons		
	bois	buvez		
	boit	*boivent*	busse	
Present Subjunctive	boive, boives, boive, buvions, buviez, *boivent*.			
connaître, *to know*		*connaissant*	*connus*	J'ai *connu*
Fut. connaîtrai		Imp. connaissais		
	connais	connaissons		
	connais	connaissez		
	connait	connaissent	connusse	
Present Subjunctive	connaisse, connaisses, connaisse, connaissions, connaissiez, connaissent.			
craindre, *to fear*		*craignant*	*craignis*	J'ai *craint*
Fut. *craindrai*		Imp. craignais		
	crains	craignons		
	crains	craignez		
	craint	craignent	craignisse	
Present Subjunctive	craigne, craignes, craigne, craignions, craigniez, craignent.			
écrire, *to write*		*écrivant*	*écrivis*	J'ai *écrit*
Fut. écrirai		Imp. écrivais		
	écris	écrivons		
	écris	écrivez		
	écrit	écrivent	écrivisse	
Present Subjunctive	écrive, écrives, écrive, écrivions, écriviez, écrivent.			
faire, *to make, do*		*faisant*	*fis*	J'ai *fait*
Fut. *ferai*		Imp. faisais		
	fais	faisons		
	fais	*faites*		
	fait	*font*	fisse	
Present Subjunctive	*fasse, fasses, fasse, fassions, fassiez, fassent.*			
prendre, *to take*		*prenant*	*pris*	J'ai *pris*
Fut. prendrai		Imp. prenais		
	prends	prenons		
	prends	prenez		
	prend	*prennent*	prisse	
Present Subjunctive	prenne, prennes, prenne, prenions, preniez, prennent.			
vivre, *to live*		vivant	*vécus*	J'ai *vécu*
Fut. vivrai		Imp. vivais		
	vis	vivons		
	vis	vivez		
	vit	vivent	vecusse	
Present Subjunctive	vive, vives, vive, vivions, viviez, vivent.			
vaincre, *to conquer*		*vainquant*	*vainquis*	J'ai *vaincu*.
Fut. vaincrai		Imp. vainquais		
	vaincs	vainquons		
	vaincs	vainquez		
	vainc	vainquent	vainquisse	
Present Subjunctive	vainque, vainques, vainque, vainquions vainquiez, vainquient.			

Below are the less irregular verbs. They are given under the same headings as the others, and only the parts are given about which there is likely to be any doubt. The forms not given can be obtained by the usual rules. It has not been considered necessary to give the Present tense in full, as in practically all cases the singular is identical throughout except for the ending, which is *-is*, *-is*, *-it* if the 1st person is *-is*, and *-s*, *-s*, *-t* if the 1st person is *-s*. Sometimes the first person is *-x*. Then instead of *s*, *-s*, *-t* we

have *-x*, *-x*, *-t*. In the plural, if there is any departure from the 1st person stem it is given.

INFINITIVE	PRES. INDIC. SING.	PRES. PART.	PAST DEF.	PAST PART.
fuir, to flee	fuis	*fuyant* fuyons fuient	*fuis*	*J'ai fui*
acquérir, to acquire	acquiers	*acquérant* acquérons acquièrent	*acquis*	*J'ai acquis*
(Subjunctive acquière, acquérions, acquièrent.)				
haïr, to hate	hais	*haïssant* haïssons	*haïs*	*J'ai haï*
bouillir, to boil	bous	*bouillant* bouillons	*bouillis*	*J'ai bouilli*
faillir, to fail	faux, -x, -t	*faillant* faillons	*faillis*	*J'ai failli*
vêtir, to clothe	vêts	*vêtant* vêtons	*vêtis*	*J'ai vêtu*
mouvoir, to move	meus meuvent	*mouvant* mouvons		*J'ai mu*
pleuvoir, to rain	pleut	*pleuvant*	*il plut*	*Il a plu*
pourvoir, to foresee	pourvois	*pourvoyant* pourvoyons pourvoient	*pourvus*	*J'ai pourvu*
asseoir, to seat	assieds, -s assied	*asseyant* asseyons	*assis*	*J'ai assis*
(Subjunctive asseye, asseyions. Future assiérai.)				
conclure, to conclude	conclus	*concluant* concluons	*conclus*	*J'ai conclu*
mettre, to put	mets	*mettant* mettons	*mis*	*J'ai mis*
couvrir, to cover		*couvrant* couvrons	*couvris*	*J'ai couvert*
ouvrir, to open		*ouvrant*	*ouvris*	*J'ai ouvert*
souffrir, to suffer		*souffrant*	*souffris*	*J'ai souffert*
offrir, to offer	offre	*offrant*	*offris*	*J'ai offert*
cueillir, to pluck *cueillerai* (Fut.)	cueille	*cueillant* cueillons	*cueillis*	*J'ai cueilli*
assaillir, to assail	assaille	*assaillant* assaillons	*assaillis*	*J'ai assailli*
dire, to say	dis	*disant* disons, dites disent	*dis*	*J'ai dit*
lire, to read	lis	*lisant* lisons	*lis*	*J'ai lu*
rire, to laugh	ris	*riant* rions	*ris*	*J'ai ri*
plaire, to please	plais plaît	*plaisant* plaisons	*plus*	*J'ai plu*
confire *suffire*	confis	*confisant* confisons	*confis*	*J'ai confit* *J'ai suffi*
(*confire* = to preserve, *suffire* = to suffice.)				
coudre, to sew	couds	*cousant* cousons	*cousis*	*J'ai cousu*
moudre, to grind	mouds	*moulant* moulons	*moulus*	*J'ai moulu*
suivre, to follow	suis	*suivant* suivons	*suivis*	*J'ai suivi*
vaincre, to conquer	vaincs vainc	*vainquant* vainquons	*vainquis*	*J'ai vaincu*
(Subjunctive vainque.)				
battre, to beat	bats	*battant* battons	*battis*	*J'ai battu*

** 8. **The Negative and the Interrogative.**—There are still two general uses of the verb to be explained: when it makes a negative statement, and when it asks a question. It is possible that these two may be combined. Both uses are quite simple, and a few instances will suffice to illustrate them.

Nous aimons toujours ceux qui nous admirent, et nous
We love always those who admire us, and we
n'aimons pas toujours ceux que nous admirons.
do not like always those whom we admire.

La vertu n'irait pas si loin, si la vanité ne lui tenait (pas
Virtue would not go so far if vanity did not keep it
compagnie.
company.

Here we have examples, as we already saw in the introductory lesson, of the fact that it takes two words to make a negative—'no,' the genuine negative, and 'pas,' or some other complementary word.

Note the place of these two words: they enclose the verb.

Nous N'aimons PAS ceux qui nous admirons.
La vertu N'irait PAS si loin.

This is their normal position. If a personal pronoun object comes before the verb, then it also is included between the negatives.

Je NE vous ai jamais vu.
I have never seen you.

In a question the negative words maintain same place, although the verb and pronoun are inverted.

Turpin, N'as-tu RIEN vu dans le fond du torrent?
Turpin, hast thou seen nothing in the torrent bed?

Notice here also the place of the negatives when the verb is composed of an auxiliary and a participle. The auxiliary is looked on as the verb, the participle is only a complement. The negatives enclose the auxiliary. Sometimes the complementary negative word will be found in another part of the sentence.

Thus in the phrase 'Rien ne va plus,' *Nothing goes (any) more*, the complementary word is 'rien,' which is here the subject of the sentence, and so stands at its head.

Both negative particles usually stand before an Infinitive, as one is continually reminded in French railway carriages: 'Ne pas se pencher en dehors.'

We have seen that the commonest negative complement is 'pas.' This really means *a pace*, and it would be used with verbs of motion

originally. There were other complements—'goutte,' *a drop*; 'mie,' *a crumb*—which would be used when appropriate, but 'pas' has gradually ousted them. We have a somewhat similar use in English when we say, *Not a bit, Not a scrap.*

But there are times when the complementary of the negative has a definite use. We have already had two instances, 'jamais' and 'rien.' Here is the list:

Jetez mes cendres dans le Rhone; je *n'ai jamais* visité Marseilles.
Throw my ashes into the Rhone; I have never visited Marseilles.

On *ne* donne *rien* si libéralement que ses conseils.
One gives nothing so liberally as advice.

Si nous *n'*avons *point* d'orgueil nous ne nous plaindrons pas de celui des autres.
If we have no pride we do not complain about that of others.

*Rien n'*empeche tant d'être naturel que le désir de le paraître.
Nothing prevents so much being natural as the wish to be so.

Le style *n'*est *que* l'ordre et le mouvement dans ses pensées.
Style is only the order and the action one puts into one's thoughts.

Tous les preux étaient morts, mais *aucun n'*avait fui.
All the heroes were dead, but none had fled.

C'est pour *ne pas* avoir assez réfléchi sur son objet qu'un homme d'esprit *ne sait* par où commencer. Il aperçoit à la fois un grand nombre d'idées, et comme il ne les a NI comparées, NI subordonnées, *rien ne* le détermine à préférer les uns aux autres.
It is from not having thought enough on his subject that a man of brains does not know where to begin. He perceives at once a great number of ideas, and as he has neither compared nor subordinated them, nothing determines him to prefer one to others.

We see from these examples that:

'ne . . . rien' signifies *nothing.*
'ne . . . point' „ *none.*
'ne . . . que' „ *only* (*no, but*)
'ne . . . jamais' „ *never.*

'Aucun' is the adjective complementary to the negative. Here it is used as a pronoun.

Notice that *nor . . . nor* is 'ni . . . ni,' and also that 'sait' does not take a complementary—a property it shares with 'oser' and 'pouvoir.'

The Verb Interrogative

This will be best shown by the partial conjugation of a few verbs. Attention should be paid to the difference when a noun is the subject and when a pronoun:

parlé-je français, parlez-vous français, parle-t-il français? parlons-nous français, parlent-ils français?

Note the accent introduced on to the last *e* of 'parlé-je,' and the *t* intercalated in 'parle-t-il.' Both are for euphonious reasons.

Ex.—Mon frère, assiste-t-il à cette conférence? Non. Mon frère, a-t-il assisté à cette conférence? Mon frère, assistera-t-il à cette conférence?
Ai-je bien dormi, avez-vous bien dormi, avons-nous bien dormi, ont-ils bien dormi, etc. etc.

Frequently the question is asked by this formula:

Est-ce que vous parlez français, mademoiselle?
Is it that you speak French, Miss?
Oui, monsieur. Est-ce que monsieur est un étranger (*foreigner*)?

This style may be specially recommended to a foreigner, as it does away with the necessity of inverting the pronoun and the verb, a process often involving some confusion in the mind of the beginner.

It is not infrequent to find the question conveyed by the inflexion of the voice. Thus mademoiselle above might have said simply:

Monsieur est étranger, sans doute?

The Interrogative Negative somewhat more formidable. Here are some cases with 'dire,' *to say.*

Ne dis-je pas? ne dis-tu pas? ne disons-nous pas? ne dites-vous pas? ne disent-ils pas? Mon oncle, ne dit-il pas? mes tantes, ne disent-elles pas?

And when a pronoun object interposes this can be very awkward.

Je dis toujours — Quoi? Qu'est-ce que vous dites toujours? J'ai dit toujours—Oui, oui, oui, oui; vous l'avez déjà dit. Qu'est-ce que je vous ai déjà dit?—Mais ce que vous avez dit?—Je ne vous ai jamais dit—Vous ne m'avez jamais dit.—Je vous dis que je ne vous ai jamais dit quoique ce soit.—Me dites-vous, ou ne me dites-vous pas ce que vous m'avez dit?—Vous l'ai-je jamais dit?—Mais ne me l'avez-vous pas dit cent fois?	I always say — What? What is it that you always say? I have always said—Yes, yes, yes, yes; you have said it already—What have I said to you already?—Why, what you have said?—I have never said to you—You have never said to me—I tell you that I have never said to you anything whatever.—Do you say to me or do you not say to me what you have said?—Have I ever said to you?—But have you not said it to me a hundred times?

But here it is the reason rather than the knowledge of verb forms which gives out.

9. The Passive.—By reason of its compound form the Passive is rather avoided in French. We will see presently how it can be avoided, and content ourselves at present with seeing how it is used.

Soldats — says Napoleon — vous n'avez rien fait, puisqu'il vous reste encore à faire. Les cendres des vainqueurs des Tarquins *sont* encore *foulées* par les assassins de Basseville. *Vous étiez dénués* de tout au commencement; *vous êtes* aujourd'hui abondamment *pourvu.* Les plus grands obstacles *sont franchis*, sans doute; mais vous avez encore des combats à livrer.	Soldiers, you have done nothing, since there still remains something to do. The ashes of the vanquishers of the Tarquins are still trampled on by the assassins of Basseville. You were stripped of everything at the beginning; you are to-day abundantly provided for. The greatest obstacles are cleared, doubtless: but you have still combats to engage in.

We see from this that, as in English, the Passive is composed of the Past Participle of the verb following the verb *to be*, 'être.'

** **10. The Reflexive Verb.**—In reading these following lines we shall notice repeatedly a peculiarity about the verbs which has perhaps already given some slight occasion of wonder:

* Sur ce même fond anglais se peignait au Nord des nuances toutes contraires. C'est dans les colonies anglaises du Nord que se sont combinées les deux ou trois idées principales qui aujourd'hui forment les bases de la théorie sociale des Etats-Unis. Les principes de la Nouvelle-Angleterre se sont d'abord répandus dans les Etats voisins; ils ont fini, si	On this same English background were depicted in the north quite different shades. It is in the English colonies of the north that are brought together the two or three principal ideas which form to-day the base of the social theory of the United States. The principles of New England spread first in the neighbouring states: they finished, if I

je puis m'exprimer ainsi, par pénétrer la confédération entière. . . . Les émigrants qu vinrent s'établir sur les rivages de la Nouvelle Angleterre appartenaient tous aux classes aisées de la mère patrie. Leur réunion presenta le singulier phénomène d'une société où il se trouvait ni riches ni pauvres. Tous avaient reçu une éducation assez advancée, et plusieurs d'entre eux s'étaient fait connaître en Europe par leur talents et leur science. Les autres colonies avaient été fondées par des aventuriers sans famille; les émigrants de la Nouvelle Angleterre se rendaient au desert accompagnés de leurs femmes et de leurs enfants. . . . Ils s'arrachaient aux douceurs de la patrie pour obéir à un besoin purement intellectuel; en s'exposant aux misères de l'exil, ils voulaient faire triompher une idée.—TOCQUEVILLE.

may say so, by penetrating the whole confederation. The emigrants who came to establish themselves on the shores of New England all belonged to the well-to-do classes of the mother country. Their union presented the singular phenomenon of a society in which were neither rich nor poor. All had received a fairly advanced education, and several of them had made themselves known in Europe by their talents and their knowledge. The other colonies had been founded by adventurers without families: the colonists of New England went into the desert accompanied by their wives and their children. They tore themselves from the sweetness of the homeland in obedience to a purely intellectual need; in exposing themselves to the miseries of exile they wished to make an idea triumph.

We find 'se poignaient,' *there depicted themselves*; 'se sont combinés,' *were combined* (lit. *combined themselves*); 'se sont répandus,' *spread themselves*; 'je puis m'exprimer,' *I can express myself*. Later we have 's'établir,' *to establish themselves*; 'se trouvait,' *were found* (lit. *found themselves*); 's'étaient fait,' *had made themselves*; 'se rendaient,' *repaired*; 's'arrachaient,' *tore themselves*; 's'exposant,' *exposing themselves*.

What is the sum of what we learn from these examples? First of all, this, that the reflexive —*self, selves*—is much more used in French than English. Sometimes it is as a substitute for the passive ('se sont combinés'), and sometimes there does not seem any need for the reflexive at all (a French tooth-powder 'instructions for use' tells one, for example, to 'se rincer la gorge et de se gargariser'). It is, in fact, especially with the parts of the body that the reflexive is used. *Cp.* 'se moucher,' *to wipe one's nose*; 'se boucher les oreilles,' *to stop the ears*; 'se laver,' *to wash*; 'se peigner,' *to comb* (*the hair*).

It will have been noticed that the auxiliary is 'être,' not 'avoir,' as with a passive verb; but the participle agrees with the pronoun object, not with the subject, and then only if it is the direct object. Thus it would be 'elle s'est lavé les mains,' but 'elle s'est lavée,' the reflexive in the first place being only indirect object.

** 11. **The Participles.**—The Past Participle is used, as we have already seen, to form the compound tenses of the verb, in conjunction with the auxiliaries 'avoir' and 'être.' Beyond this the participles have two uses: (1) simply as adjectives; (2) to form participial phrases. In this latter use there is still some difference according to whether the use is chiefly adjectival or chiefly verbal. The Present Participle shows this difference by agreeing or not agreeing with the noun to which it refers. Here are some instances:

chanté	fini	reçu	dormi	rompu
chantant	finissant	recevant	dormant	rompant

* Le vaste bateau glissait, jetant sur le ciel, qui semblait ensémencé d'étoiles, un gros serpent de fumée noire: l'eau agitée par l'helice remuait tant de clartés qu'on eût dit de la lumière bouillant. Nous étions là, silencieux, admirant, l'œil tourné vers l'Afrique. . . . Alors un grand homme à figure brûlée, un de ces hommes qu'on sent avoir traversé de longs pays inconnus, au milieu de dangers incessants et dont l'œil tranquille semble garder quelque chose des pays étranges qu'il a vus; un de ces hommes qu'on devine trempés dans le courage.—MAUPASSANT.

The huge boat glided, throwing across the sky, which seemed sewn with stars, a huge serpent of black smoke: the water disturbed by the screw stirred up so many gleams, that (it seemed like) a boiling light. We were there, silent and admiring, the eye turned towards Africa. Then a tall sunburnt man, one of those men who one feels has travers d wide and unknown lands, in the midst of incessant dangers, and whose steady eye seems to retain something of the strange lands he has seen: one of those men who one divines to be steeped in courage.

'jetant,' 'ensémencé,' 'agitée,' 'bouillant' are all semi-verbal; 'admirant' and 'tourné' are verbal—or predicative, as it is called, *i.e.* the participle is used instead of a verb to lighten the phrase and to make the main thread more distinct. 'brûlée' is purely adjectival; 'traversé' forms with 'avoir' the Past Infinitive; 'inconnu' is adjectival, as is 'incessants.' '*vus*' is, you will notice, plural. It is so because the object of the verb is a pronoun and precedes the participle. This use will be frequently met, but it is not worth much attention, as it is now allowed to make the participle not agree even under these conditions. 'trempés' is predicative. It will be noticed that 'bouillonant' does not agree with 'lumière,' which is feminine; this is because it is predicative. So in the same way 'admirant' is not plural, although it refers to *we*.

Past Participles

This extract should furnish all the material we require on the Past Participle:

La nature paraît avoir négligé certains animaux, qui par imperfection d'organes sont condamnés à endurer la souffrance, et destinés à éprouver la penurie. Enfants disgraciés, nés dans le denûment pour vivre dans la privation. . . . Le héron nous presente l'image d'une vie de souffrance. N'ayant que l'embuscade pour tout moyen d'industrie il passe des heures immobile au point de laisser douter si c'est un être animé . . . il paraît comme endormi, posé sur une pierre, le corps presque droit, le cou replié le long de la poitrine, la tête et le bec couchés entre les épaules, et s'il change d'attitude c'est pour en prendre une encore plus contrainte en se mettant en mouvement.—BUFFON.

Nature seems to have neglected certain animals, who by the imperfection of (their) organs are condemned to endure suffering, and doomed to experience want. Ill-favoured children, born in nakedness to live in privation . . . the heron presents to us the image of a life of suffering. Having only ambush as his sole means of labour, he passes hours motionless, so as to make it doubtful if he is even alive . . . he appears asleep, perched on a stone, the body almost upright, the neck doubled back along the breast, the head and beak couched between the shoulders, and if he changes position it is to take up one more constrained as he sets himself in motion.

Note that 'condamnés' and 'destinés,' although forming part of a finite verb, agree with their subject: this is because their auxiliary is the verb *to be*, 'être.' In this case they are

passive; but the same would be true if they were verbs of motion, which also take the verb 'être' as their auxiliary. Notice that 'enfants disgraciés, nés . . .' are absolute phrases not having a direct connection with the rest of the sentence. The phrases 'le cou replié . . . la tête et le bec couché' are somewhat similar; but they are still descriptive of the heron, which is the subject of the sentence.

'en se mettant en mouvement.' This is a use of the Participle Present not at all as an adjective, but as a substantive, as is shown by a preposition ('en') standing in front. That is the only preposition that can do so, and it is necessary to warn the student against translating the English verbal noun in *-ing* by the French seeming equivalent, when it is preceded by any other preposition. The Infinitive must always be used.

12. **The Imperative.**—The verb can, of course, be couched in the form of a command. It will then be principally in the 2nd person—that of the person addressed. The Imperative is, in fact, the 2nd singular and the 1st and 2nd plural of the Present Indicative without the pronouns. When a command is given in the 3rd person, the Subjunctive Present is used. Here are the regular Imperatives:

parle	finis	romps	dors	reçois
parlons	finissons	rompons	dormons	recevons
parlez	finissez	rompez	dormez	recevez

The only irregular Imperative is that of 'savoir,' which is 'sache, sachons, sachez.'

For some examples of the Imperative we may take the legend which Victor Hugo gives of Cain, when he fled pursued by the Eye of Conscience. After the first flight:

Sa femme fatiguée, et ses fils hors d'haleine,	His wife fatigued, and his children out of breath,
Lui dirent, '*Couchons-nous* sur la terre et *dormons*.'	Said to him, '*Let us lie* on the ground and *let us sleep*.'

Cain, however, only rouses them to further flights, till at last even he says:

'*Arrêtons-nous*,' dit-il, 'car cet asile est sur.	'Let us stop here,' said he, 'for this refuge is sure.
Restons-y; nous avons du monde atteint les bornes.'	Let us remain here; we have reached the limit of the world.'

But again the same terrible apparition makes him call out:

'*Cachez-moi*,' cria-t-il, et, le doigt sur la bouche,	'*Hide me*,' cried he, and, the finger on the mouth,
Tous ses fils regardaient trembler l'aïeul farouche.	All his children watched their haughty sire tremble.

He bids them:

'*Étends* de ce côté la toile de la tente.'	'Stretch out this side the cloth of the tent.'

Hugo again apostrophising the Guard at Waterloo:

Ils allaient, l'arme au bras, front haut, graves, stoïques.	They went, weapon in hand, head high, grave, and stoical,
Pas un ne recula. *Dormez*, morts héroïques!	Not one recoiled. Oh sleep, heroic dead!

Mirabeau when dying:

Soutiens cette tête, la plus forte dans la France.	Hold up this head, the strongest in France.

** 13. **The Infinitive.**—The verb is the word which denotes action or existence, and it commonly is used to assert that some 'person' is in that action or state. But at times it is used simply to name the action or state, without direct reference to any person at all. In other words, the action of the verb is named, and this use of the verb as a name—or noun—is called the Infinitive. It is given this name because in this use the verb is not confined to reference to a person, but is—grammatically, at any rate—free. Other uses of the verb by contrast are called 'finite.'

Its simplest use in this way is seen in Shakespear's *To sleep, perchance to dream*, 'Dormir, et peut-être rêver'; or again, 'Savoir c'est pouvoir,' *To know is to be able*. The reader will recognise this use in the following. Mirabeau at his death-bed says to his attendant:

Je mourrai aujourd'hui; il ne reste plus qu'à s'envelopper de parfums, qu'à se couronner de fleurs, qu'à s'environner de musique, afin d'entrer paisiblement dans le sommeil eternel.	I shall die to-day; there only remains to envelop oneself in perfumes, to crown oneself with flowers, to surround oneself with music, so as to enter peacefully into the eternal sleep.

Here it will be seen that the Infinitive is not the subject, as in 'savoir c'est pouvoir,' but the complement.

These extracts will complete our study of the employment of the Infinitive:

* 1. Connaître une première nature, adorer son éternité, admirer sa toute-puissance, louer sa sagesse, s'abandonner à sa volonté, n'est-ce rien qui nous distingue des bêtes?—BOSSUET.	1. To know a first nature, to adore his everlastingness, to admire his power, to praise his wisdom, to give ourselves up to his will, is this nothing which distinguishes us from the beasts?
* 2. Il a fallu six cents siècles à la nature pour *construire* ses grands ouvrages, pour *attiéder* la terre, *pour* en *façonner* la surface et *arriver* à un état tranquille; combien n'en faudra-t-il pas pour que les hommes arrivent au même point et cessent de *s'inquiéter*, de *s'agiter* et de se *detruire?*—BUFFON.	2. It has needed six hundred centuries for nature to construct its great works, to cool the earth, to shape its surface, and to reach a state of peace; how long will it need man to arrive at the same point, and to cease to distress and disquiet himself and to destroy?
* 3. Lorsqu'on prend un héron, on *peut le garder* quinze jours *sans* lui *voir chercher* ni *prendre* aucune nourriture; il rejette même celle qu'on tente *de* lui *faire avaler*: l'apathétique héron *semble* se *consumer sans languir*; il périt *sans* se *plaindre* et sans apparence de regret.—BUFFON.	3. When one takes a heron, one can keep him a fortnight without seeing him seek or take any food: he rejects even that which one seeks to make him swallow: the sluggish heron seems to consume away without pining; he perishes without complaint and without appearance of regret.
* 4. Soldats! Les phalanx républicaines, les soldats de la liberté étaient seuls *capables* de *souffrir* ce que vous avez souffert. Mais, soldats, vous n'avez rien fait, puisqu'il vous reste encore *à faire* . . . vous avez encore des combats *à livrer*, des villes *à prendre*, des rivières *à passer*. En est-il d'entre vous qui préféreraient *retourner* sur les sommets de l'Apennin et des Alpes, *essuyer* patiemment les injures de la soldatesque	4. Soldiers! The republican phalanx, the soldiers of liberty, were alone capable of suffering what you have suffered. But, soldiers, you have done nothing, since it still remains to you to do . . . you have still battles to wage, towns to take, rivers to cross. Is there one of you who would prefer to return to the summits of the Alps and the Apennines to wipe away patiently the insults of the Slav soldiery?

esclave ? Non. Tous brûlent de *porter* au loin la gloire du peuple français, tous *veulent humilier* ces rois orgueilleux qui osaient *méditer* de nous *donner* des fers, tous veulent *dicter* une paix glorieux, tous veulent, en rentrant dans leurs villages, *pour voir dire* avec fierté : J'étais de l'armée conquerante de l'Italie.—NAPOLEON.	No. All burn to carry afar the glory of the French people, all wish to humble these haughty kings who dared to think of giving us irons, all wish to dictate a glorious peace, all wish to be able to say proudly, as they return to their villages, I was of the conquering army of Italy.

In No. 1 all these Infinitives are the logical subjects of the question.

In No. 2 they are so less directly: It required six hundred years to construct, to soften, fashion, arrive. We might express the idea : The constructions of its great works required six hundred years. Notice that in French various prepositions can introduce the Infinitive. In English *to* is dedicated to this purpose. 'Cessent de s'inquiéter,' etc. Here the Infinitive serves to develop the meaning of the verb 'cessent.' It is the logical object.

In No. 3, 'On peut le garder,' 'garder' completes the idea of 'peut.' After *can* there must be *do* something or other. Here the Infinitive is almost modal, as in *will do* it is temporal.

'sans lui voir.' Here there is an important difference between the English use and the French. As we have just said, *to* is the only preposition used before the Infinitive in English. When any other preposition is used, then in English we use the more substantival verbal noun in *-ing*. We should say *without seeing*, and later *without languishing, without complaining.*

'Chercher' and 'prendre' are what are called the Accusative Infinitive : One can keep him without seeing him seek or take any food. What do you not see ? Him taking food. The phrase is the object of *see*.

'Qu'on tente de lui faire avaler.' Here, again, what does one try to do ? To make him swallow. *Try* is also a verb which requires another verb to complete its meaning. So also is 'semble': He seems to consume. *Consume* tells you what he does; it completes the idea of 'semble,' *seems*.

No. 4. The first Infinitive here is 'souffrir': 'Only the soldiers of the republic were capable of *suffering*.' *Capable of* requires a verbal noun. In English we use the verbal noun in *-ing*. In French the Infinitive can be used after any preposition : 'Puisqu'il vous reste encore à faire.' *Since it remains (for) you still to do.* This is rather a peculiar use ; it is called the Gerundive. What remains to do, or to be done, is amplified a few lines lower down : 'Combats à livrer, villes à prendre, rivières à passer.' Note that it may be also rendered by the Passive : *Towns to be taken, rivers to be passed.* 'Retourner' is the object of *prefer*. 'Essuyer' is what they would return to do. After a verb of motion the simple Infinitive is allowed, as after *seem*, 'sembler,' or, as we see a few lines ahead, after 'veulent,' *wish*. In English we say 'return *and* wipe away.' When the following verb is quite necessary to carry out the idea of the first verb, as a rule a simple Infinitive follows. When the connection is not quite so close as we see in 'brûlent de porter' and 'méditer de nous donner,' a preposition is required. The examples[1] here, with verbs of motion, practically exhaust the list of verbs followed by a simple Infinitive, with the exception of 'savoir' and 'paraître.'

Note the use of 'faire,' *do, make*, in No. 3 : 'Il rejette même celle qu'on tente de lui *faire* avaler,' *to* '*make*' *him swallow*. There is the same use in English. 'Laisser,' *to let*, is used in the same way : 'Laissez venir à moi les enfants.' As we see here, when the object of the first verb is a noun it follows the second verb.

There is another use of the Infinitive, as a form of description. We have a similar use in English : 'And me liggin' here alone' (Tennyson). Here is a description of what might be a 'down dishes' sensation in French :

'Et aussitôt Alain de s'empresser, Georgette d'accourir, et la porte de s'ouvrir. Les marchands alors de fuir, les consommateurs de trouver les boutiques closes, et tout le monde de mourir de faim. Il s'éloigne tout honteux et nous de rire.'

SUMMARY OF INFINITIVE USES

1. As a substantive : 'Dormir et peut-être rêver.'
2. Completing the idea of a verb: 'Je ne peux pas dire.' 'Veux-tu venir ?'
3. Following an adjective : 'Capable de tout même de mourir.'
4. Accusative Infinitive, instead of a finite verb phrase : 'Je le vois passer.'
5. After 'faire' : 'A faire suivre.'
6. Historic : 'Et moi de rire.'

14. **The Subjunctive Mood.**—There is no genuine equivalent in English of the French subjunctive mood, and its use can only be learned from a careful study of typical instances.

PRESENT TENSE

(Que) je	tu	il	nous	vous	ils
parle	parles	parle	parlions	parliez	parlent
finisse	finisses	finisse	finissions	finissiez	finissent
rompe	rompes	rompe	rompions	rompiez	rompent

Note that in the singular and the 3rd plural the endings are those of the *-er* conjugation, in the case of the *-ir* conjugation the final consonant of the stem being doubled. In the *-er* conjugation the endings in the singular and 3rd plural are the same as the Present Indicative. The Subjunctive is, however, usually introduced by 'que.'

Que cet instant parmi tous les instants soit benit.—ROST.

The minor conjugations make their Present Subjunctives in this way :

(Que) je	tu	il	nous	vous	ils
dorme	dormes	dorme	dormions	dormiez	dorment
reçoive	reçoives	reçoive	recevions	receviez	reçoivent

[1] Sembler, oser, pouvoir, faire, vouloir, préférer.

Imperfect Tense

(Que) je	tu	il	nous	vous	ils
parlasse	parlasses	parlât	parlassions	parlassiez	parlassent
finisse	finisses	finît	finissions	finissiez	finissent
rompisse	rompisses	rompît	rompissions	rompissiez	rompissent

Minor conjugations :

dormisse	dormisses	dormît	dormissions	dormissiez	dormissent
reçusse	reçusses	reçût	reçussions	reçussiez	reçussent

The use of this tense in the *-er* conjugation is avoided on account of the *-asse* sound, which grates on the ear. In the *Baron de Fourchevif*, by Labiche, it strikes the bogus baron as unusual when he hears his wife, who is seeking to make an impression on an artist, using this tense. 'Tiens !' he says, 'ma femme qui soigne son style.'

The other two tenses of the Subjunctive, being compound, are similar in each conjugation. They are :

The Perfect

(Que) j'ai parlé, fini, rompu, dormi, reçu, etc.
(See conjugation of 'avoir.')

The Pluperfect

(Que) j'eusse parlé, fini, rompu, dormi, reçu, etc.
(See conjugation of 'avoir.')

There remains to consider the use of the Subjunctive mood. As it has no genuine equivalent in English, we will go straight to our texts to observe it at home. Look at the following examples :

* 1. Croyez-vous que les croisades *eussent été* possibles chez un peuple qui n'eût pas été accoûtumé à cette vie errante et aventureuse ? Concevrait-on aujourd'hui un peuple de propriétaires qui tout-à-coup se déplacât, abandonnât ses propriétés, ses familles, pour aller chercher ailleurs de telles aventures ? Rien de pareil eût été possible si la vie quotidienne des possesseurs de fiefs n'eût été, pour ainsi dire, un avant-goût des croisades, s'ils ne se fussent trouvés tout prêts pour de telles expéditions.

1. Do you believe that the crusades *would have been* possible with a people which *had* not *been* accustomed to this wandering and adventurous life ? Would one conceive to-day a people of proprietors who all at once removed, abandoned their property, their families, to go (and) seek elsewhere such adventures ? Nothing similar would have been possible if the daily life of the possessors of fiefs had not been, so to speak, a foretaste of the crusades, if they had not found themselves quite ready for such expeditions.

We see here unfamiliar forms : 'eussent été,' 'n'eût pas été,' 'se déplacât,' 'abandonnât,' 'n'eût été,' 'fussent trouvés,' Reference to the conjugations of 'avoir' and 'être' will show the forms ; but what is their use ?

Let us see how they occur. In each case we see that the mood comes in a subordinate sentence : 'Croyez-vous que les croisades eussent été possibles ?' 'Concevrait-on un peuple . . . qui se déplacât, abandonnât . . .' Then we may suppose that this mood is one 'consecrated' to subordinate sentences—that is to say, sentences which are developments of the main sentence. This is usually so.

Now, the first use we have of the mood is after the question : 'Croyez-vous ?' *Do you believe ?* And the writer evidently expects you not to believe. The second is a similar use : 'Concevrait-on ?' *Could one conceive ?* That is to say, he puts both these suggestions with a considerable element of doubt. In the third instance he uses the mood in a principal sentence, but both principal sentence and the subordinate sentence which follows it ('Nothing like it would have been possible . . . if the everyday life had not been') are unlikely suppositions. There is an *if* in the case, and the supposition is negatived. Again we have doubt and unlikelihood.

2. L'Amerique est le seul pays où l'on *ait* pu assister aux developpements naturels et tranquilles d'une société et où il *ait* été possible de préciser l'influence exercée par le point de départ sur l'avenir des Etats.

2. America is the only country where one has been able to witness the natural and peaceful development of a society, and where it has been possible to fix the influence exercised by the starting-point on the future of the States.

Agrippine to her Son Nero, professing Herself willing to Die

3. Agrip. *Pourvu que* par ma mort tout le peuple irrité
Ne vous *ravisse* pas ce qui m'a tant coûté.
Ner. Hé bien, donc, prononcez ! Que voulez-vous *que je fasse ?*
Agrip. De mes accusateurs qu'*on punisse* l'audace,
Que de Britannicus on *ca me* le courroux,
Que Junie à son choix *puisse* prendre un époux.—Racine.

3. Agrip. Provided that by my death all the people enraged
Does not despoil you of what has cost me so much.
Ner. Well, then, pronounce ! What would you that I do ?
Agrip. Of my accusers that the boldness be punished,
That the anger of Britannicus be appeased,
That Junica be able to take the husband of her choice.

Boileau bewailing the Set against Molière

4. *Avant qu'*un peu de terre obtenu par prière
Pour jamais sous la tombe *eût enfermé* Molière.

4. Before a little earth obtained by prayer
For aye 'neath the tomb had enclosed Molière.

Molière went out of fashion. To gratify any natural curiosity as to what *did* happen :

"Le commandant voulait la scène plus exact.
Le vicomte indigné sortait au second acte."

5. Quoique je ne *sorte* presque jamais, j'ai une passion demésurée de connaitre tous les anciens chemins qui étaient du temps des Romains. Il y en a un près de chez moi, et je ne manque jamais d'y passer *quoiqu'il soit* incommode et qu'il m'*allonge* de plus d'une lieu.—Montesquieu.

5. Though I hardly ever go out, I have an inordinate passion for knowing all the ancient roads which were at the time of the Romans. There is one of them near my house, and I never fail to pass that way, although it is inconvenient and lengthens my journey by more than a league.

A Pious Wish of Boileau

6. Maudit *soit* le premier dont la verve insensée
Dans les bornes d'un vers renferma la pensée.

6. Cursed be the first whose insensate zeal
Confined thought to the limits of verse.

7. J'allai alors d'un pas tranquille chercher quelque lieu désert où *rien* ne montrant la main des hommes n'*annoncât* la servitude et la domination, *quelque* asile où je *puisse* croire avoir pénétré le premier et où nul importun ne *vint* s'interposer entre la nature et moi.—Rousseau.

7. I went then with a tranquil step to seek some desert place where nothing by revealing the hand of man should announce servitude and domination, some asylum where I might believe (myself) the first to have penetrated and where no importunate person should come to interpose between me and nature.

Geneva under Calvin

8. Situation unique d'alarmes continuelles. Il fallait se garder des ennemis, bien plus des amis, veiller toujours, craindre toujours. Voilà

8. A unique situation (and one) of continual alarms. It was necessary to guard oneself from enemies, even more from friends, to watch always, to

pourquoi Genève a *été* la vierge sage. Voilà pourquoi elle a été la grande école des nations. Mais pour qu'il fût ainsi il fallait qu'elle *subît* une transformation complète, qu'elle *s'abjurât* d'elle-même, que d'une ville de plaisir elle se *fît* la fabrique des saints, la sombre forge où se *forgeassent* les élus de la mort.—MICHELET.	fear always. That is why Geneva has been (*i.e.* was) the wise virgin. That is why she has been the great school of nations. But for it to be so it was necessary that she should undergo a complete transformation, that she should deny herself, that from a pleasure city she should make herself the manufacture of saints, the sombre forge where were produced the elect of death.
9. Oh, qui que vous soyez, parlez moi, je m'abhorre. Qui que vous soyez, Spectres qui m'entourez, démons qui nous voyez. HUGO.	9. Oh, whoever you may be, speak to me, I abhor myself, Whoever you may be, Spectres that surround me, demons that behold us.

In No. 2 we do not seem to have this doubt: 'America is the only country where one has been able to assert . . . where it has been possible to fix . . .' The use here is more formal. The French argue that the Indicative is the mood in which you state that *things are:* if you mention them without affirming that they are so, they look on this statement as still supposititious. If the writer had said, 'One has assisted in America alone at the natural development,' that is a statement, and so Indicative. But he says not, 'Où on a pu assister,' but something a little less. In English, if you want to render the idea, you must say, 'Where one has had the opportunity of assisting'; then you do not imply actually that one did do so. That is to say, in English, which is an analytic language, you always use words to express your meaning, and not forms, as in French, which is a more synthetic language. English, again, is not so precise. In the first example, in English we should say, 'If the possessors of fiefs had not been . . . .' We consider all the supposition has been conveyed by the *if,* which really means *gif, give, grant that,* and so we are content to assume the thing granted for a fact. The French use is, as a rule, the same after *if,* 'si'; but when the supposition is clearly unlikely, then the Subjunctive is required. If in English we feel the unlikelihood is so marked as to require being expressed in the verb, we have, as a rule, to use auxiliaries and to say, as in No. 1, 'Do you believe that the crusades would have been possible? Could one conceive a people which would displace itself, abandon its lands . . . '; or, with our greater fluidity, we might say, 'Could one conceive a people displacing itself, abandoning . . .'

But even in French the Subjunctive is not used always when a thing is mentioned without being related as a fact. It is only when it is mentioned with an element of doubt that the Subjunctive is required. And as French is a formal language, the occasions when the Subjunctive are used are rather apt to be crystallised as being after certain kinds of expressions.

The consideration of the remaining examples will give us the idea of what these expressions are.

No. 3. 'Pourvu que le peuple ne vous ravisse.' *Provided that the people does not despoil you.* Here, we see, there is a 'concession' made by the use of 'pourvu que.' The statement of the despoiling is dependent on that, and so the Indicative is evidently not the mood to use, although in English it is. *What do you wish that I should do?* says Nero. 'Que voulez-vous que je fasse?' We have already seen that the Infinitive can be used after 'vouloir.' In English we should rather say, *What do you wish me to do?* But in French *me to do* would be too clumsy a phrase, and the Infinitive can only be used if the second verb has no subject. 'Que voulez-vous faire?' would be all right, but 'Que voulez-vous me faire?' is not logical enough for the French. We shall find these differences illustrated later. Notice that Agrippine in stating what she wishes keeps in the Subjunctive: 'Qu'on punisse,' etc.

No. 4. 'Avant qu'un peu de terre eût enfermé Molière.' Has it yet done so? No; not in the statement of the writer as to what happened. (See p. 258, No. 4.) 'Avant que,' *before,* naturally does not take the mood of statement, the Indicative.

No. 5. 'Quoique je ne sorte.' The concessive 'quoique' requires the Subjunctive, as we see in the next line, 'Quoiqu'il soit incommode et qu'il m'allonge,' because it is inconvenient—if and when he does pass. The English *it may be convenient* is too strong to express the difference.

No. 6. 'Maudit soit le premier.' *Cursed be the man.* Here the Imperative borrows a person from the Subjunctive to supply one which it lacks. None the less we see that it is from another point of view the expression of a wish that something should be.

No. 7. 'Où rien n'annonçât la servitude et la domination.' What kind of a sentence is it? It is in reality a relative sentence, 'où,' *where* —*i.e.* by, at which—having a relative character. A relative clause is frequently put into the Subjunctive if it is not a mere relative of convenience —*i.e.* attributive, or adjectival.

'Où je puisse croire.' Here we should have expected the Indicative, at any rate, if the phrase had stood by itself, because 'pouvait' has a slight suggestion by itself of a thing not actually happening. (It is a similar word, *might,* which we use in English to render the idea of the Subjunctive). But the writer has already shown that the whole idea is unlikely, and so 'puisse' is attracted into the mood of the previous phrase. In the next phrase, 'Où nul ne vînt,' we have again an indefinite relative, as above. If the reader will compare this use with that shown in No. 9, he will see 'qui que' —called an Indefinite Relative—and its indefiniteness naturally makes it the typical relative, which does not state a fact, but makes a suggestion. In fact, the Indefinite Relative really asks what may be called a Scotch question.

In the last line of this quotation we have two relatives of convenience, as I have called them; 'Spectres qui m'entourez, démons qui nous voyez': they do surround him, they do see us; and the relative simply makes, as it were, the statement that they do.

No. 8. This last extract is both important and interesting. We find at first the verb 'falloir' followed by the Infinitive, and then afterwards by the Subjunctive. But it is not necessary for us to be puzzled by that. We have found 'vouloir,' *to wish* or *want*, doing the same thing, and remember that it was when it took a whole sentence to say what was wanted that the Subjunctive was needed. The same thing is true of the kindred verb 'falloir,' *it needs*, as the reader will see if he reads the extract through.

It is not necessary to repeat anything about the mood of 'forgeassent' after 'où.' Notice, however, the Subjunctive appearing after 'pour que.' We have already had an instance of this in Agrippine's speech.

And now, in conclusion, let it be said that there are signs that the French people are a little tired themselves of their Subjunctive. It tends to be used only in the Present and Past Indefinite, and there is an effort to avoid it. We have noticed that if a whole sentence is not coming after, the Infinitive can replace it after 'vouloir' and 'falloir.' The same is true of a number of other verbs; and even the conjunctions, such as 'avant que,' 'afin que,' 'pour que,' 'sans que,' may be replaced by the prepositions 'avant de,' 'afin de,' 'pour,' 'sans,' *when the subject of the following verb is the same as that of the preceding one.*

Summary of Subjunctive Uses

1. After a verb expressing doubt, or desire, or wish.
2. In a relative sentence when the statement is mentioned hypothetically and not vouched for, or if a negative has preceded the relative clause.
3. After certain conjunctions which themselves imply that it is not an Indicative statement which is being made.
4. To express a wish or a command.

** 15. **Personal Pronouns.**—It is best to memorise at once the forms given below before commencing the study of their uses.

Nom.	Acc.	Dat.	Emphatic Form
je, *I*	me, *me*	me, *(to) me*	moi
tu, *thou*	te, *thee*	te, *(to) thee*	toi
il, *he*	le, *him*	lui, *(to) him*	lui
elle, *she*	la, *her*	lui, *(to) her*	elle
nous, *we*	nous, *us*	nous, *(to) us*	nous
vous, *you*	vous, *you*	vous, *(to) you*	vous
ils, *they*	les, *them*	leur, *(to) them*	eux
elles, *they*	les, *them*	leur, *(to) them*	elles

Note.—The emphatic forms are used when the pronouns are not used in conjunction with the verb. Example:

'Me! that have been what I have been!'
Moi! qui, etc.

or after prepositions:

A moi, mes hommes!
To me, my men!

The Possessive Adjectives and Possessive Pronouns

Adjectives	Pronouns
mon, ma, mes, *my*	le mien, la mienne, *mine* Pl. les miens, les miennes
ton, ta, tes, *thy*	le tien, la tienne, *thine* Pl. les tiens, les tiennes
son, sa, ses, *his, her, its*	le sien, la sienne, *his, her, its* Pl. les siens, les siennes
notre, notre, nos, *our*	le nôtre, la nôtre, *ours* Pl. les nôtres
votre, votre, vos, *your*	le vôtre, la vôtre, *yours* Pl. les vôtres
leur, leur, leurs, *their*	le leur, la leur, *theirs* Pl. les leurs

The different forms for the different numbers and genders are due to the fact that in French the possessive adjective or pronoun takes its gender or number from the *thing possessed*, not *the possessor*, as in English.

Instances of the pronouns in their simplest forms may be found in the sections devoted to the tenses of the verbs. We will now enter on a more detailed examination of the various uses and forms of pronouns—personal, relative, interrogative, and demonstrative—with their corresponding adjectives. In the case of these latter, attention must be paid to them, not because they do not follow the general rule of adjectives, but because they do so to a more marked degree than do their English equivalents.

However, once more to our texts. Here is a passage well worth studying:

* La Conscience	The Conscience
Rentrons en *nous-mêmes;* examinons, tout intérêt personnel à part, à *quoi* nos penchants *nous* portent. *Quel* spectacle *nous* flatte le plus, celui des tourments ou du bonheur d'autrui? *Qu'est-ce qui nous* est le plus doux à faire, et *nous* laisse une impression plus agréable après l'avoir fait, d'un acte de bienfaisance ou d'un acte de méchanceté? *Pour qui vous* interessez-*vous* sur *vos* théâtres? Est-ce aux forfaits que *vous* prenez plaisir? Est-ce à *leurs* auteurs que *vous* donnez des larmes? Tout nous est indifférent, dites-*vous*, hors *notre* intérêt: et, tout au contraire, les douceurs de l'amitié, de l'humanité, *nous* consolent dans *nos* peines; et, même dans *nos* plaisirs *nous* serions trop seuls, trop misérables si nous n'avions *avec qui* les partager. S'il n'y a rien de moral dans le cœur de l'homme, d'où *lui* viennent donc ces transports d'admiration pour les actions héroïques? Cet enthousiasme de la vertu, *quel* rapport a-t-*il* avec notre intérêt privé? Pourquoi voudrais-je être Caton *qui* déchire ses entrailles, plutôt que César triomphant? Otez de nos cœurs cet amour du beau, vous ôtez tout le charme de la vie. Celui *dont* les viles passions	(Let us) come back to ourselves: (let us) examine—all personal interest apart—to what our leanings bring us. What spectacle pleases us most, that of the torments or of the happiness of another? What is it which is the nicest for us to do, and leaves us a most agreeable impression after having done it, an act of kindness or an act of evil? For whom do you interest yourself at your theatres? Is it at the villainies that you take delight? Is it to their authors that you give your tears? All is indifferent to us, you say, outside our own interest: and quite on the contrary, the sweets of friendship, of humanity, console us in our troubles: and even in our pleasures we should be too solitary, too miserable, if we had not (anyone) with whom to share them. If there is nothing moral in the heart of man, whence come to him, then, these transports of admiration for heroic actions? This enthusiasm for virtue, what relation has it with our private interest? Why should I wish to be Cato who rends his entrails, rather than Cæsar triumphant? Take away from our hearts this love of the beautiful, and you take away all the charm of life. He whose vile passions have stifled in his narrow soul these delicious sentiments, he who by force of concentrating on him-

ont étouffé dans son âme étroite ces sentiments délicieux, celui *qui*, à force de *se* concentrer au dedans de *lui* . . . le malheureux ne sent plus, *il* ne vit plus, *il* est déjà mort. Mais quelque soit le nombre des méchants sur la terre, *il* est peu de ces âmes cadavereuses devenues insensibles hors leur intérêt, à tout *ce qui* est juste et bon. Si quelque acte de clémence ou de générosité frappe *nos* yeux, *quelle* admiration, quel amour il nous inspire ! *Qui est-ce qui* ne se dit pas : *J'en* voudrais avoir fait autant ? *Il* nous importe assurément fort peu qu'un homme ait été méchant ou juste il y a deux mille ans . . . *Que me* font à *moi* les crimes de Catilina ? Ai-je peur d'être sa victime ? Pourquoi donc ai-je de *lui* la même horreur que s'il était *mon* contemporain ? *Nous* ne haïssons pas seulement les méchants parce qu'ils *nous* haïssent, mais parce qu'ils sont méchants. Non seulement nous voulons être heureux, nous voulons aussi le bonheur d'autrui ; et, quand ce bonheur ne coûte rien au nôtre, il l'augmente. Enfin, l'on a, malgré soi pitié des infortunés ; quand on est temoin de leur mal, on en souffre. Les plus pervers ne sauraient perdre tout à fait ce penchant ; souvent il les met en contradiction avec eux-mêmes. . . . Il est donc au fond des âmes un principe sur *lequel nous* jugeons *nos* actions . . . et c'est à ce principe *que* je donne le nom de Conscience.—Jean Jacques Rousseau.

self alone . . . the wretch feels no more, he lives no more, he is already dead. But whatever the number of the wicked on earth, there are few of these corpse-like souls (which have) become insensible, beyond their own interest, to all which is just and good. If some act of clemency or of generosity strikes our eyes, what admiration, what love it inspires us (with). Who does not say, Yet I would I had done as much ? It matters little indeed to us that a man has been good or bad two thousand years ago. . . . What matter to me the crimes of Catiline ? Have I any fear of being his victim ? Why, then, have I the same horror as if he were my contemporary ? We do not hate the wicked because they hate us, but because they are wicked. Not only do we wish to be happy, we wish also the happiness of others : and when this happiness costs nothing to ours, it augments it. In fine, one has, in spite of oneself, pity for the unfortunate : when one is witness of their ill, one suffers from it. The most perverse 'could not' lose altogether this inclination : often it puts them in contradiction with themselves. . . . There is, then, at the bottom of (our) hearts a principle upon which we judge our actions . . . it is to this principle that I give the name of Conscience.

We will now address ourselves to the crop of pronouns which we find in this 'morceau.' Let us take first the pronouns personal. As we know them in the nominative, they are : 'Je,' *I* ; 'tu,'[1] *thou* ; 'il,' *he* ; 'elle,' *she* ; 'nous,' *we* ; 'vous,' *you* ; 'ils,' 'elles,' *they*. In l. 1 we find 'nous-mêmes' for *ourselves*, and in l. 4 'nous' for *us* (object), while in l. 26, after numerous 'nous' = *us*, there is a 'nous serions,' *we should be*, l. 28 'nous avions,' *we had*. Going back to l. 14, we have 'vous intéressez-vous'—*i.e.* 'vous' standing for *you* as subject and object. (Note that the second *you* must be *yourself* in English.) In l. 29 we have 'il' for *it* (in French indistinguishable from *he* or *she*), and in l. 32 'lui' for *him*. But in l. 11 we have 'l''—*i.e.* 'le' for *it* (object)—which ought to be identical with *him*. True, but 'lui' here is indirect object. We have it in l. 48 after 'de.' In l. 38 there is 'je,' *I*, and in l. 68 'que me font à moi'—*me* (object), and 'moi,' *me* (after a preposition). In l. 76 we have 'ils,' *they* ; in l. 28 'les,' *them* ; and in l. 91, after a preposition, 'eux-mêmes,' *themselves*. (The plural of 'lui' (indirect object), of which we have not met an instance, is 'leur.') It will be useful for the learner to collect all the instances of each of the persons of the pronouns, tabulating them according to whether they are subject, object, indirect object, or after a preposition. The forms we have obtained so far are :

	1st Person		2nd Person	3rd Person		Fem.
	Sing.	*Plur.*	*Plur.*	*Sing.*	*Plur.*	
Subject	je	nous	vous	il	ils	*elle, elles*
Object	me	nous	vous	le	les	*les*
Ind. Object	me	nous	vous	lui	*(leur)*	*leur*
After a Prep.	moi	nous	*toi, vous*	lui	*(eux)*	*elles*

In italics are the forms not found here.

But as well as the personal pronouns we must also give an eye to the pronominal adjectives. As we have said these have a very important difference from the English. This will be perhaps best brought out by taking another sentence. 'La mérite de la femme,' said De Maistre, 'est de régler *sa* maison, de rendre *son* mari heureux, et d'élever *ses* enfants,' *The merit of woman is to rule her house, to render her husband happy, and to bring up her children.* In English we say *her* in each case, but in French it is 'son' with 'mari,' a masculine singular word, 'sa' with 'famille,' a feminine singular, and 'ses' with 'enfants,' a plural word. The rule is evidently that the possessive adjective takes its gender from the thing possessed, not from the possessor. We will now see what instances there are of these adjectives in our original passage.

In l. 3 we have 'nos penchants' (plural) ; in l. 15 'vos théâtres' (also plural) ; in l. 17 'leurs auteurs,' *their authors* (plural) ; in l. 21 'notre intérêt,' *our interest* (here singular) ; in l. 45 'son âme' (singular) ; in l. 39 'ses entrailles' (plural) ; in l. 71 'sa victime' (feminine singular) ; in l. 68 'mon contemporain' (masculine singular) ; in l. 86, 'leur mal' (masculine singular). Tabulating these, we get :

	1st Person		2nd Person		3rd Person	
	Sing.	*Plur.*	*Sing.*	*Plur.*	*Sing.*	*Plur.*
Masculine	mon	notre	*(ton)*	*votre*	son	leur
Feminine	*ma*	*notre*	*(ta)*	*votre*	sa	*(leur)*
Pl. (M. and F.)	*mes*	nos	*(tes)*	vos	ses	leurs

And we shall be justified in filling in the missing forms on the analogy of those we have discovered.

There exist, then, distinct forms for the masculine and feminine of the singular possessives, and for the plural one form for the masculine and feminine ; while of the plural possessives there is one form for the masculine and the singular, and one for the plural. (Note that it is the *-e* mute termination which prevents a distinction being shown between the masculine and feminine of 'notre' and 'votre,' while 'leur' does not take a sign for the feminine, although it does for the plural.)

We now turn to the relative and interrogative pronouns. The principal forms are : 'qui,' *who* ('l'homme qui rit,' and 'Qui va la ?') :

[1] We shall only find 'tu' in intimate language.

'que,' *whom, that* ('Fou que vous êtes'), which is also interrogative in reference to things ('Que voulez-vous ?'). We must also be prepared for the fact that French having no neuter words, such as *which, what,* these will be rendered by masculine or feminine forms. It is, however, in the relative and demonstrative forms that one finds traces of a neuter and neuter uses. And now, 'revenons à nos moutons.'

In the first three sentences of 'La Conscience' we find 'à quoi,' *to(wards) what ;* '*quel spectacle*' (interrogative adjective); '*qu'est-ce qui,*' *what is it which* (an intensive interrogative); '*pour qui,*' *for whom ;* 'aux forfaits *que* vous prenez plaisir ?' *is it to the villanies that you take pleasure ?* In l. 28 we have 'avec *qui,*' *with whom* (relative); in l. 35 '*quel* rapport'; in l. 38 'Caton *qui* déchire' (relative); in l. 40 'dont,' *of whom, whose* (relative); in l. 47, 'celui qui,' *he who* (relative); in l. 56 'tout ce *qui* est juste,' *all (that) which* (relative); in l. 60 '*quelle*' (feminine); in l. 61 '*quel*' (masculine adjective); in l. 62 '*Qui est-ce qui ?*' (again the intensive interrogative, this time used of a person: *cp.* '*Qu'est-ce qui,*' of a thing); in l. 68 '*Que* me font,' *What does it make to me ?* (interrogative); and in l. 93 a new form, '*sur lequel,*' *upon which* (relative).

Tabulating these forms, we notice that, as a rule, there is no distinction of gender in relatives or interrogatives, except in the adjectives 'quel,' 'quelle.' On the other hand, 'quoi,' *what,* shows us that there are special words to be used in a neuter sense, and a moment's reflection will tell us that there must be. 'Lequel' suggests, however, that in this form there is distinction of gender, and so perhaps of number also. Here are the forms we have obtained :

	RELATIVE	INTERROGATIVE
Subject	Qui, ce qui, *that which, he who*	Qui and Qui est-ce qui ?
Object	Que, *whom, which*	Que (referring to a thing)
After a Prep.	Qui	Quoi
Possessive.	Dont, *of whom*	*Inter. Adj.* Quel, quelle, quoi, *what* (referring to an object)

We have also one instance of another form : 'lequel' . . . un principe . . . sur lequel nous jugeons nos actions.'

It will be seen that we must reinforce these instances, as they do not altogether cover the uses of the relative and the interrogative. What, for instance, was the extent of the use of this 'lequel' ? If 'lequel' in one place presumably 'laquelle' in another, and elsewhere 'lesquels,' 'lesquelles.' Here are some further instances of 'lequel,' etc.

LES FABLES	THE FABLES
* 1. Les enfants y reconnaissent les mœurs du chien qu'il caressent, du chat dont ils s'abusent, de la souris dont ils ont peur. Pour les animaux féroces, ils y trouvent ce que leur mère en a dit, le loup dont on menacent les mauvais enfants, le renard qui rode autour du poulailler, le lion dont on leur a vanté les mœurs clémentes. Ils s'amusent singulièrement des petits drames dans *lesquels* figurent ces personnages. . . . Les plus avisés, ceux devant *lesquels* on ne dit rien impunement, vont plus loin.—NISARD.	1. The children recognise there the habits of the dog which they caress, of the cat which they misuse, of the mouse of which they are afraid. (As) for the wild animals, they find there what their mother has said, the wolf with which one threatens the naughty children, the fox which prowls around the fowl-run, the lions of whom has been exalted the manners mild (!). They amuse themselves highly with the little dramas in which these characters figure. The more wary, those before whom one does not say anything with impunity, go farther.
2. Je crois volontiers les histoires dont les témoins se font égorger.	2. I believe willingly the stories of which the witnesses get their throats cut.
3. Je viens à vous Seigneur, Père *auquel* il faut croire.—V. HUGO.	3. I come to you, Sire, Father in whom one must believe.
4. Parmi les antiquités les plus touchants du Louvre il est un morceau de marbre *sur lequel* on distingue deux jeunes filles qui tiennent à la main chacune une fleur.—A. FRANCE.	4. Among the most touching antiquities of the Louvre there is a piece of marble on which one can see two children who each hold in (their) hand a flower.
5. Il est juste que ce qui est juste soit suivi. Il est necessaire que ce qui est le plus fort soit suivi.—PASCAL.	5. It is right that that which is right be followed. It is necessary that that which is strongest be followed.

Now what can we gather from the various uses of 'lequel,' etc., in these passages ? We have 'le principe sur lequel, . . . les drames dans lesquels, . . . les (enfants), ceux devant lesquels on ne dit rien, . . . père auquel il faut croire, . . . les histoires dont, . . . un morceau de marbre sur lequel.' This is evident, that 'lequel' is used after a preposition. The fact that it is a form which shows difference of gender suggests also that it is used to remove any possible ambiguity which may arise. As a matter of fact, it must be used when the relative relates to a thing, and it is used in reference to persons when two nouns have come before, and the gender may help to show to which of these two it refers. Thus, in this sentence from Mignet, the historian, speaking of the dying Calvin :

Il se fit porter de son lit à la table autour *de laquelle* étaient ses collègues, *auxquels* il dit en entrant.	He had himself brought from his bed to the table around which were his colleagues, to whom he said on entering. . . .

Here 'à qui' might suggest that he was addressing the table, which, however, would properly be 'à laquelle.'

In the same passages we have several uses of 'dont' illustrated. In No. 1 we have 'dont on s'abusent,' in English *which one misuses,* not *of which,* as in 'dont ils ont peur,' *of which they are afraid.* Again, 'le loup dont on menace les mauvais enfants,' *with which one threatens naughty children.* In 'le lion dont on a vanté' we have *of whom one has vaunted ;* and in No. 3, 'les histoires dont les temoins,' *stories of which the witnesses.* So we may see that 'dont' is used impartially of persons and things, or of gender or number. But in this sentence we find it absent (it is still Calvin) :

Le delabrement de son estomac ne lui permettait pas de prendre en 24 heures plus d'un repas, à la suite duquel, il retournait à l'étude.	The ruin of his (digestion) did not permit him to take in 24 hours more than one meal, at the end of which he returned to study.

Why is not 'dont' used here? If it was, as 'dont' always comes after its antecedent directly, it would be 'dont à la suite'—an awkward phrase. So 'duquel' replaces 'dont' in the same way that 'lequel' does 'qui,' when there is awkwardness or ambiguity.

(*N.B.*—In the same extracts it is worth noticing the use of 'ce que,' 'ce qui.' We have in No. 1 'ce que leur mère en a dit,' and in No. 5 'ce qui est juste, . . . ce qui est le plus fort.' We see that where in English we are content with simply saying *what their mother has said*, *what is just, that which is stronger*, in French they always say *that which*, giving a word for the object and for the subject.)

** 16. **Adverbs.**—Adverbs not being subject to inflexion, do not present much material difference to their English equivalents. But we shall find it useful to notice three things about them: first, how they are commonly formed; secondly, their position in the sentence; thirdly, their meaning and its bearing on the sentence. Here are some examples:

* 1. Le style n'est que l'ordre dans les pensées. Si on les enchaîne *étroitement*, si on les serre, le style devient ferme, nerveux et concis; si on les laisse succéder *lentement*, et ne se joindre qu'à la faveur des mots, le style sera lache et traînant . . . lorsque (un écrivain) se sera fait un plan . . . les idées se succéderont *aisément*, la chaleur se répandra *partout*, et donnera de la vie à chaque expression, tout s'animera de *plus en plus*: et le style deviendra intéressant et lumineux.—Buffon.	Style is only order in (one's) thoughts. If one connects them closely, if one compresses them, the style becomes firm, nervous, and concise; if one lets them follow slowly, and only join by means of words, the style will be slack and dragging . . . when (a writer) has made a plan . . . the ideas will follow easily, warmth will spread throughout, and give life to each expression; all will be more and more animated, and the style will become interesting and luminous.
* 2. Après avoir été *longuement* et *injustement* détenue prisonnier dans ce pays, ou j'ai *beaucoup* enduré de peine et de mal, *maintenant* par la force et sous la puissance des hommes, prêté à finir ma vie . . . devant une compagnie qui sera temoin que, bien près de la mort, j'ai protesté comme je l'ai *toujours* fait, soit en particulier, soit en public, de n'avoir *jamais* rien inventé pour faire périr la reine ni consenti à rien contre sa personne.—Marie Stuart.	For translation see Verb, Present tense, p. 250.

Collecting the adverbs, we find they are: 'étroitement,' 'lentement,' 'aisément,' 'partout,' '(de) plus en plus,' 'longuement,' 'injustement,' 'beaucoup,' 'maintenant,' 'toujours,' 'jamais.' It is evident from this list that a great number of adverbs are formed by the termination *-ment*, and a little reflection will show that these are, as a rule, formed from the adjective which gives the attribute to the noun, which is here given to the verb. Adverbs, in fact, do the same thing for verbs which adjectives do for nouns. And they are like adjectives in this respect: they can be comparative or superlative. Notice that it is from the feminine of the adjective that they are formed ('étroi*te*ment,' 'long*ue*ment'). See example below:

3. Les accusations de cette sorte (impiété) étaient *fort* nombreuses à Athenes; c'est le genre de causes qu'on trouve *le plus frequemment* dans les orateurs attiques. Aristote, Aspasie, Euripède furent *plus ou moins sérieusement* inquiétés.—Renan.	Accusations of this sort were very numerous at Athens: it is the kind of case most frequently found in the Attic orators. Aristotle, Aspasia, Euripides were more or less seriously perturbed.

Harking back to the list of adverbs we got from the previous extracts, we see that, apart from being formed from adjectives, adverbs are formed (as 'par-tout,' 'beau-coup') by a compressed prepositional phrase or a noun joined to some other word and used in an adverbial sense. In fact, in Ex. 2 the difference is only one of degree, by which 'comme je l'ai toujours fait' and the following phrases are as adverbial as 'maintenant.' Both modify the verb to which they are attached.

The position of the adverb is well defined. Its normal place is after the verb. If it is not there, it should go at the head of the sentence.

Maintenant que du deuil qui m'a fait l'âme obscure Je sors, pâle et vainqueur.	Now that from the grief which has obscured my soul I come, pale but triumphant.

Adverbs must never stand in front of the verb, as they do commonly in English. In a compound tense their place is after the auxiliary and before the participle, unless they are of ungainly proportions. We have already noticed this in the negative complement—those expressions being also adverbs.

En somme, malgré les exactions des gouverneurs et les violences inséparables d'un gouvernement absolu, le monde, sous bien des rapports, n'avait pas encore été aussi heureux.—Renan.	To sum up, in spite of the exactions of governors, and the violence inseparable from an absolute government, the world, under quite a number of counts, had not been so happy before.

In the above phrase the reader will find a perfect plethora of adverbial expressions, modifying not only verbs, but, as is also their function, adjectives and other adverbs.

With regard to the meaning of adverbs, they naturally divide themselves into answers to the questions *where? when? why?* and *how?* In this latter capacity they will often call in question or considerably weaken the statement of the verb, and in consequence lead to the Subjunctive Mood. The reader can refer to the section on that mood to see this.

** 17. **Prepositions.**—Adverbs lead on to prepositions, for prepositions joined to nouns supply answers to those questions—*Where? why? when?* and *how?*—which it is the general function of adverbs to answer.

Although prepositions in French and English roughly correspond, yet the idiom of the language often demands that one preposition shall be used in one language where in the other it is a different one.

Thus we say *from time to time;* in French they say 'de temps en temps.' We say *to snatch from someone;* they say 'arracher *à* quelqu'un.'

The two prepositions with the most extensive and varied uses are 'à' and 'de.' 'De' means *of, from,* and at times *with* and *by.* Look at these lines:

* 1. Oh que si cet hiver un rhume salutaire, Guérissant *de* tous ses maux mon avare beau-père, Pouvait bien confessé, l'étendre dans un cercueil, Et remplir sa maison *d'*un agréable deuil. Que mon âme, en ce jour *de* joie et *d'*opulence, *D'*un superbe convoi plaindrait peu la depense. La mort vient *de* saisir le vieillard catarrheux, Voilà son gendre riche; en est-il plus heureux?	1. Oh that this winter a convenient cold would cure of his ills my father-in-law, and stretch him in his shroud—if he'd made a good death—and fill all his house with a comfortable regret. How my heart in that day of joy and of wealth would grudge little the cost of a grand funeral! Death has just seized the wheezing dotard, his son-in-law's rich; is he the happier for it?

Here we find special uses of 'de':

* 2. Il demandait pour grâce unique *de* prêcher, *de* mendier, *de* n'avoir rien au monde, sauf une pauvre église de Sainte-Marie-des-Anges, dans le petit champ de la Portioncule, qu'il rebatit *de* ce qu'on lui donnait.	2. He asked the single favour of preaching and begging, to have nothing in the world but a poor church of St. Marie of Angels, in the little field of the Portiunculo, which he rebuilt with what was given him.
3. La pieté n'a rien *de* faible, ni de triste, ni de gêné.	Piety knows nothing of weakness, sadness, nor want.

In No. 1 'de' follows 'guérissant,' *curing from* or *of.* 'D'un deuil' is either *with* or possibly *of* (making it *full of*). The next three 'de's' are *of.* The 'de' which follows 'vient' is a peculiar one. 'Venir de' means originally *to come from.* Thence it means *to have just done* a thing.

In No. 2 the 'de's' follow 'demander.' One asks *to* someone, *of* doing something! The reason is to be found in the radical meaning of 'demander'; it is to give a command *to* someone, the command being one *of* doing something. 'De ce qu'on lui donnait.' Here 'de' is *with.*

No. 3. This is a redundant use of 'de' *nothing (of) feeble,* etc.

Remember, also, that words denoting quantity are followed by 'de':

Dans mon coffre, tout *plein de* rares qualités, J'ai cent mille vertus en louis bien comptés.	In my coffer, all full of qualities rare, I have 100,000 virtues in well-counted Louis.

This passage, beside giving a number of the uses of 'à,' affords examples of a number of other common prepositions:

* La Révolution commença *à* se faire homme. *Pendant* la première époque du gouvernement consulaire, Bonaparte s'attacha les classes proscrites *en* les rappelant; il trouva un peuple encore agité de toutes les passions, qu'il ramena *au* calme *par* le travail, *au* bien-être *par* le retablissement de l'ordre; enfin, il força l'Europe *à* reconnaître son élévation. *Jusqu au* traité d'Amiens, il rappela dans la République la victoire, la concorde, le bien-être, *sans* sacrifier la liberté. La nation était *entre* les mains du grand homme ou du despote; il dépendait de lui de la conserver affranchie ou de l'asservir. Il aima mieux l'accomplissement de ses projets égoïstes, et il se préféra tout seul *à* l'humanité entière. Elevé *sous* la tente, venu tard *dans* la Révolution, il ne croyait ni *aux* besoins moraux qui l'avait fait naître, ni *aux* croyances qui l'avaient agitée et qui tôt ou tard devaient revenir et le perdre. Il vit un soulevement qui prenaient fin, un peuple fatigué, qui était *à* sa merci, et une couronne *à* terre, qu'il pouvait prendre.—MIGNET.	The Revolution began to mature. During the first part of the consular rule Bonaparte secured the proscribed classes by recalling them; he found a people still agitated with all kinds of passions, whom he reduced to calm by work, to well-being by the re-establishment of order; in fine, he forced Europe to recognise his rise. Till the Treaty of Amiens he revived in the State victory, peace, and happiness, without sacrificing liberty. The nation was in the hands of the great man or the despot; it depended on him to keep it free or enslaved. He preferred the carrying out of his selfish projects, and he put himself before humanity. Reared in the tent, a late-comer in the Revolution, he believed neither in the moral needs which had produced it, nor in the faith which had stirred it, and which sooner or later would return and destroy him. He saw an uprising drawing to a close, people weary and at his mercy, and a crown on the ground for him to pick up.

'à' means, in the first place, *to* and *at.* But it serves, in addition, to complete many verbs and adjectives (*cp. scissors to grind, ready to go*), as we shall see in this passage.

The first time it occurs it completes 'commença,' joining 'commença' with 'se faire.' In English, when one verb follows another, the two are always linked by *to,* unless the connection is so close as to require no linking word, as, *you can go, he must come;* in French 'à' is only one of several prepositions which can be so used. Note the other instances of this use in the passage. In 'il crut ni aux besoins ni aux croyances,' the idiom is a little different to ours. We believe *in* a thing; they believe *to*—'à une chose.'

'à terre.' This is also an idiom. We say, *on the ground.*

The commonest prepositions which we have not yet discussed are:

'après,' *after.* 'Après la pluie le beautemps,' *After the rain fine weather.*

'avant' and 'devant,' which both mean *before.* 'Avant' with time: 'avant hier,' *before yesterday;* 'avant trois heures.' 'Devant: 'Je passe devant vous.'

'chez,' *with,* or *at the house of,* as one says. 'Chez moi,' *at home.*

Il en est chez le duc, il en est chez le prince, L'ouvrage le plus plat a chez les courtisans De tout temps rencontré de zélés partisans.	'Tis so at the duke's, 'tis so with the prince. The dullest of works has among courtiers Encountered at all times the strongest upholders.

'contre,' *against.* 'Cent contre un,' *A hundred against one.* 'Le pour et le contre.'

'derrière,' *behind.* 'Derrière un mamelon la garde était masséo' (Hugo), *Behind an earthwork the guard was massed.*

'pour,' *for.* 'Avez-vous quelquechose pour moi?' *Have you something for me?*

'vers,' *towards.* 'Vers l'avenir, vers la liberté,' *Towards the future, towards liberty.*

'à travers,' *across, through.* 'A travers (de) ma chambre,' *Across my room.*

III.—IDIOMS

[For reasons of space illustrative extracts will not be given.]

Idiom of the Noun.—1. Use of *proper names.* In referring to families or individuals in the plural, in French one says, 'les Stuart' 'les Bourbon,' without making the noun plural.

2. *Capital letters* are not used in writing days, months. 'dimanche, mercredi; janvier, juin.'

3. *Time* is frequently expressed without a preposition. 'Je pars *dimanche en huit,*' *Sunday week.* 'Je rentre le soir.'

4. (*cp.* 'il y a huit jours,' 'quinze jours,' *a week, a fortnight ago*).

5. Note, 'soirée' and 'matinée' denote *evening* or *morning* in extension, with reference to duration of time. 'matin' and 'soir' connote more definitely the time or occasion.

6. Definite time is expressed by 'à'; 'à sept heures,' 'à midi.' 'Vers sept heures le soir,' *towards* 7 P.M.; 'vers minuit,' *towards midnight.*

7. Countries usually take the article. 'La France, La Grande Bretagne, Les Etats-Unis.'

8. Going to a country is expressed by 'en' simply ('Je vais en Italie'), going to a town by 'à' ('Je vais à Paris' and 'Je suis à Londres'). When the country is not a genuine proper name, 'à' is used with the articles. 'aux Indes,' *to the Indies;* 'aux Etats-Unis.'

9. In speaking of a person's occupation the article is not used. 'Il est médecin,' 'J'étais simplement matelot.'

10. Notice the adverbial. 'en bon soldat,' *acting as—in his character as—good soldier;* 'en bon garçon.'

11. But in 'en famille' the prepositional force is more marked.

Many idioms are formed by a preposition and a noun:

12. à pied, *on foot.*
13. à quatre pattes, *on all fours.*
14. au grand jour, *in broad daylight.*
15. en plein air, *in the open air.*
16. en plein mer, *on the open sea.*
17. en enfance, *in childhood.*
18. en verité, *in truth.*
19. en effet, *in fact.*
20. de notre temps, *in our time.*
21. de nos jours, *nowadays.*
22. de temps en temps, *from time to time.*
23. de jour en jour, *from day to day.*
24. dans le temps, *in the time* (past).
25. de l'autre côté, *on the other hand.*
26. une boîte *à* lettres, *a letter-box.*
27. une tasse à thé, *a teacup.* une tasse *de* thé, *a cup of tea.*
28. *aux* panaches énormes, *with huge plumes.* (A common use this.)

Idiom of Adjectives.—Remember that emphatic and many-syllabled adjectives follow the noun, and that proper adjectives do not take a capital. (For 'de' with adjectives—'ce qu'il y a de vrai,' 'de bon'—see Prepositions, 'de.') There are many adjectives in common use which form part of the stock of expressions in every French mouth. They are, as a rule, used with 'c'est' or 'il est.' Here are the commonest:

c'est vrai, *it is true.*
c'est evident, *it is evident.*
c'est certain, *it is certain.*
c'est curieux, *it is curious, strange.*
c'est triste, *it is sad.*
c'est horrible, *it is horrible.*
c'est épatant (slang), *it's stunning.*
c'est immonde, *it's beastly.*
c'est honteux, *it is shameful.*
c'est connu, *it is (well) known.*
c'est douteux, *it is doubtful.*
c'est drôle, *it is funny.*
c'est bon, *it is good.*
c'est bien, *it is well.*
c'est épouvantable, *it is awful.*
c'est ignoble, *it is disgraceful* (disgracieux is *ungraceful*).
c'est affreux, *it is frightful.*

Note the difference between 'c'est' and 'il est' in these expressions. 'Il est' is strictly impersonal, *it is.* 'C'est' is, literally, *this is* or *that is,* and consequently the thing pointed out (or demonstrated) as *this* or *that* must be immediately apparent or already expressed. When a noun is the complement, you may always say 'c'est' ('c'est dommage,' *it's a pity*); when it is an adjective, 'il' is used, if it is quite clear that a definite subject is being referred to as 'ce.' Thus 'il est evident que vous êtes ici,' but 'vous êtes ici, c'est evident.' None the less, 'c'est' seems to encroach upon 'il est.'

Idiom of the Pronoun.—Remember that in the singular and in the 3rd plural a more 'emphatic' form is used when the pronoun is away from the verb. These are: 1st, 'moi'; 2nd, 'toi'; 3rd, 'lui' (fem. 'elle'); 3rd plural, 'eux' (fem. 'elles'). Examples: 'c'est moi,' *it is I;* 'qui l'a fait'; 'lui.' The same forms are used after prepositions.

[Note that as indirect object 'lui' = *him* and *her,* 'leur' = *them* (masc. and fem.). In the emphatic form 'elle,' 'elles' must be used for *her* and *them* (fem.).]

Redundant object. In French, in answer to the question, *Are you the one?* the answer is, 'Je *le* suis.' *Did he do it?* 'Est-ce qu'il l'a fait?' 'Oui, il l'a fait.' This 'le' will sometimes turn up unexpectedly (*cp.* the Scottish *that's so*).

Idioms of the Relative.—1. There is a French expression ('Jean qui rit, et Jean qui pleure, *Jean who laughs and cries;* 'Paris qui chante,' *Singing Paris;* 'Paris qui dort,' *Sleeping Paris*) which is more often rendered in English by a participle or some other paraphrase. *e.g. London at play* would be 'London qui joue.'

2. In certain elliptical expressions a relative does double duty in French. 'Qui dort dine,' (*He*) *who sleeps dines*—the maxim on the strength of which the French army does without breakfast. So 'Qui vivra verra,' *Who lives will see.*

3. But as a rule the two components of the expression *he who* or *that which* must be expressed in French even when they would not be in English. 'Celui qui vous parle,' *He who speaks to you;* 'ce que je te demande,' *what I ask you;* 'ce qu'il a fait,' *which he did, what he did.*

4. The interrogatives 'qui' 'que' (of a thing), are reinforced frequently by 'Qui est-ce qui

(l'a fait) ?' 'Qu'est-ce qu'il a fait ?' Who did it ? What did he do ?

The Idiom of the Demonstrative.—1. In French the adjective 'ce' ('cet,' 'cette') does duty for *this* or *that* thing. Where it is necessary to distinguish between the two, this is done by adding *-ci* and *-la* to the following noun. Thus: 'dans ce cas-ci,' *in this case*; 'dans ce cas-là,' *in that case*. Plural 'ces cas-ci,' 'ces cas-là.'

2. The same distinction is made with *this* or *that* when they are pronouns by adding *-ci* and *-la* directly as suffixes. Thus: 'celui-ci, celle-ci; celui-là, celle-là; ceux-ci, ceux-là; celles-ci, celles-là.'

3. The neuter forms, 'ceci' and 'cela,' are used when the object is not so defined. 'Ceci est vraiment remarquable,' 'Cela est curieux.' In these cases, we can see, both 'ceci' and 'cela' are intensified forms of 'ce' (pronoun), whose use was explained in conjunction with adjectives.

4. Note the colloquial expression 'ça' (abbreviation of 'cela') *that*.

ça me va, *that suits me*.	ça m'est égal, *it's (all) the same to me*.
ça y est, *that's it, that's got it*.	ça ne fait rien, *that makes nothing, that does not matter*.
ça me convient, *that suits me*.	
c'est ça, c'est cela, *that is it, it is so (very well)*.	

and the ubiquitous comme ça, *like that* (*so*).

5. For 'c'est' see Idiom of Adjective.

6. 'ce' is sometimes used redundantly in French. 'Vivre seul c'est triste' *To live alone (that) is sad*. 'Vivre, c'est remplir son être,' *To live (that) is to fulfil one's being*.

7. 'ce' remains singular, although a plural complement changes 'c'est' to 'ce sont.' 'Ce sont les cadets de Gascogne.'

Idioms of the Adverb.—Remember the place of the adverb is after the verb, and in a compound tense usually before the participle.

1. Certain adverbs, however, follow the participle, as do adverbial phrases. Such are: 'hier,' *yesterday*; 'demain,' *to-morrow*; 'ici,' *here*; 'là,' *there*; 'tard,' *late*; 'tôt,' *soon*.

2. For purposes of convenience long adverbs in *-ment* also follow the participle.

3. The following are very common adverbial expressions.

4. 'peu à peu,' *little by little*; or 'petit à petit.'

5. 'beaucoup,' *much*. 'Merci beaucoup,' *Thank you very much*. You never say 'très beaucoup' in French. (Remember, when 'beaucoup' is followed by a noun, 'de' connects the two.) 'Beaucoup de fois,' *many times* (lit. *much of times*). So 'peu de fois,' *few (of) times*; 'tant de fois,' *so many times*.

6. 'combien,' *how much*, is often an interrogative adverb. 'Combien de temps y a-t-il que nous n'avons pas reçu des nouvelles de St. Petersbourg ?' *How much time is it that we have not received any news from St. Petersburgh ?* 'Combien de capitaines, et combien de marins,' *How many captains, and how many sailors ?*

7. 'jamais,' literally *ever*, is used elliptically for *never*. So 'au plus grand jamais,' *never ever*, and 'jamais de la vie,' *never in (of) the life*.

'si' as adverb means *so*. 'Si morne et si fière,' *so sad and proud*.

8. *Soon* in a general sense is 'tôt'; 'bientôt,' *presently*. 'Je me couche tôt,' *I go to bed early*.

Late is 'tard.' 'Vous travaillez tard le soir,' *You work late (in) the evening*.

'plutôt' is *sooner*, or *rather*.

9. Note the difference between 'plus que,' *more than*, in such phrases as 'Je l'aime plus que vous,' *I love him more than you*; but 'J'ai plus *de* cinquante soldats de plomb,' *I have more than fifty lead soldiers*. So 'presque,' *nearly* (*e.g.* 'presque jamais,' *nearly never*); but 'près de vingt metres,' *nearly twenty metres*.

10. There are many adverbial phrases compounded with 'tout.'

tout à fait, *altogether (entirely)*.	tout de suite, *directly*.
tout d'un coup, tout à coup, *all at once, suddenly*.	tout de même, *all the same*.
	toute à l'heure, *in a moment*.

'Tout' also = quite:

tout doucement, *quite gently*.
tout tranquillement, *quite peacefully*.

11. Distinguish between 'enfin,' *finally* (*anyhow ?*); 'à la fin,' *at the end* (*of something*); 'à fin,' *in order to*; 'au bout,' *at the end of an object* (but 'Je suis au bout de mes forces,' *I am at the end of my strength*); 'au fond,' *at bottom, fundamentally*.

12. 'bien,' *well*, is very widely used in French.

Je vois très bien, *I see very well*.	Je tenais bien la corde, *I was holding the cord well (tightly)*.
Faites bien attention, (*Now mind*), *Pay attention well*.	Vous avez bien fait, *You have done very well*.
J'ai bien vu, *I distinctly saw*.	

13. Remember that *quick* and *quickly* are both 'vite' in French.

14. These adjectives are used as adverbs in the following expressions:

sentir bon, *to smell 'good.'*	marcher droit, *to walk straight*.
parler bas, *to speak low*.	dire vrai, *to speak truly*.
coûter cher, *to cost dear*.	venir exprès, *come on purpose*.

Idioms of Verbs.—*Semi-Modal Verbs.*—1. 'devoir,' *ought*, implies obligation; 'falloir,' *to need*, necessity. 'devoir,' we may say, implies 'must' in a moral sense, which may not be carried out; 'falloir' is 'must' in the sense of 'needs must where the devil drives.' Il faut' is impersonal, but one may say 'il me faut' for *I need*. 'Il me faut une hache,' *I want an axe*.

2. 'pouvoir.' Note the expression 'ça se peut,' *that may be*. Pourriez-vous m'indiquer,' *Could you point out to me*, has some element of politeness in it. If you said 'Pouvez-vous' to a Frenchman, he *might* say 'Yes' and walk on, for you have not asked him to do it! 'Auriez-vous la bonté de,' *Would you have the goodness to*, would ensure him doing his best for you.

'veuillez,' *would you,* is a form more confined to correspondence.

3. 'vouloir.' Note the expression 'Je veux bien,' *I am quite willing—i.e. I don't mind.*

'en vouloir à quelqu'un' is *to wish (ill) to someone.* 'Je ne vous en veux pas,' *I don't bear you a grudge (for it).*

4. 'savoir' is used in the conditional to mean *be able.* 'Je ne saurais (pas) vous dire,' *I couldn't tell you.* Note, 'Que je sache,' *As far as I know.*

5. 'avoir' makes the following idioms:

avoir tort, *to (be) wrong.*	avoir froid, *to (be) cold.*
avoir raison, *to (be) right.*	avoir chaud, *to (be) warm.*
avoir honte, *to (be) ashamed.*	avoir besoin, *to (be) in need.*

'Avoir' replaces 'être' here, because 'tort,' 'froid,' 'besoin,' are nouns, not adjectives.

General.

1. 'aller,' *to go,* has semi-modal and general uses.

Future.—'Je vais le faire,' *I am going to do it.* 'Je vais vous dire,' *I will tell you.* 'Il va pleuvoir,' *It is going to rain.* This always implies a near future.

General.—'Ça va ?' *That goes? That suits?* (used as a salutation). So 'Comment allez vous,' *How do you (do)?* 'Je vais très bien.' 'Ça me va comme tout' (colloq.), *That suits me perfectly.*

2. 'se porter' is more stylish. 'Je me porte très bien.' 'Je me porte comme le pont neuf,' *I'm as fit as the new bridge.*

3. 'se tenir' is *to hold oneself.* 'Il se tient très bien.' 'Se tenir de bout,' *To stand—on end!* 'Tenir à quelqu'un, *To hold to someone,* means to think a lot of him.

4. 'penser' is *to think,* if you really think. If you only have an impression, the word is 'croire,' *believe.* 'Je crois bien,' *I suppose so.* To think seriously, or to think about, is 'songer.' To be lost in thought is to be 'songeur.' But a thinker is 'un penseur.'

5. 'savoir' is *to know, to understand.* A 'savant' is a learned man. 'Connaître' is *to be acquainted with,* though a 'connoisseur' is one who knows a thing well (Note the curious idiom: 'Je ne connais que lui,' I know him so well that *I know no one but him.*) 'Savoir-faire' is *to know how to do things,* and 'savoir' is *learning.*

6. 'venir de,' *to come from,* has acquired the meaning of *to have just done something.*

'Prendre,' *to take,* has many uses foreign to us. 'Prenez-garde!' *Take care!* 'Prendre un taxi,' *to take a taxi.* 'Prendre une tasse de thé,' *to take a cup of tea.* Or, generally, 'prendre quelque chose à manger, à boire,' *to take something to eat, to drink.*

Note the following familiar French expressions: 'faire savoir' *to (let) know;* 'faire sortir,' *to make to come out;* 'faire venir,' *to make come;* 'faire comme si on savait,' *to 'make' (act) as if one knew;* 'faire semblant,' *to pretend;* 'faire sauter' (*to make jump*), *to blow up;* 'faire faire,' *to make (someone) do;* 'ça fait,' *that makes, that amounts to.*

'Défendre,' *to forbid.* 'Défense de fumer.' (There is a place in Paris where 'Défense d'entrer' is rendered in English, *Nothing to see.*)

'constater,' *to notice, conclude, determine.*

'présenter,' *to introduce.*

'servir à' ('ça sert à'), *to be used for, to serve as.*

'se précipiter,' *to rush.*

's'empresser,' *to hasten, to be keen on something.*

's'en aller,' *to 'be off.'* 'Je m'en vais,' *I go away.*

's'endormir,' *to go to sleep.*

IV.—SOME SIMPLE RULES FOR PRONUNCIATION

1. Pronounce the vowels pure. The Continental pronunciation of the vowels is generally more defined than the English.

A is the open-mouth sound.
E is the half open-mouth sound.
I is the nearly closed mouth sound.
O is the sound of the open mouth with the lips not in their natural position for A, but rounded.
U is a sound coming from a mouth nearly closed, with the lips advanced. (Written in French OO. French U is different.)

When the mouth takes up the position for any vowel, it remains in that position while the vowel is being uttered, whereas in English the mouth begins to utter the sound as it is opening, goes on while it is in the vowel position, and when it is shifting to the next sound position. This is pronouncing the vowel impurely.

2. The second rule is a derivation of the first. It is: Form the syllables, as far as possible, consonant+vowel, consonant+vowel.

Thus 'ra-pi-di-té,' not, as in English, 're-pid-it-y.' It will be seen that of necessity it helps the vowel to be pure, if it is not made the medium of pronouncing a consonant behind and before it.

Compare the results of saying 'gé-né-ral' or 'gen'rul,' 'h'a-bi-ta-ci-on' or 'habi-tayshun.' [1]

This rule cannot be applied universally, as we see in the final syllables of 'gé-né-ral' and 'h'a-bi-ta-ci-on,' where the last syllables are *-ral, -on.* But it has produced certain important developments in French.

(i.) The common non-pronunciation of final consonants: 'blan(c),' 'pré(t),' 'chan-ge-(nt).' [Note that the final vowels which are pronounced

[1] I am necessarily using here the popular phonetic understood by every one and used boldly by all dialect writers.

are the easy ones, least likely to jar the preceding vowel, *-el*, *-en*, *-et*.]

(ii.) The *running on* of a consonant from a previous word to the initial vowel of the next word. To take an extreme case :

Nou(s) lè-sa-von-plan-té-sen-sem-bl(e).
Nous les avons plantés ensemble.

(iii.) The conservance of the *e* mute, so called, as a minimum sound, used simply as a means of voicing a previous consonant (a 'voyelle d'appui'). Compare 'abundance' with French 'a-bon-dan-ce,' where the final *e* has not entirely lost its sound.

3. The tonic accent in French—*i.e.* the accent on the syllable comes on the last syllable. Thus 'Ra-pi-di-TÉ,' not 'raPIDity,' as in English. Our method tends to huddle the other syllables round the accented one, and the other vowels get slurred in consequence. In French even the accent on a final syllable is lost in speaking and a tonic accent only survives on the final syllable of a short phrase, or at the natural pauses in a long sentence. Thus: 'Qu'avez vous FAIT ?' *What have you done?* 'J'ai perdu mes enFANTS,' *I have lost my children.* So from the point of view of diction the division between words is relatively small. It is as if the sentence were looked on as the unit, not the word.

It is this which makes French difficult to follow. It seems to glide out in an uninterrupted stream, and the listener gets left hopelessly behind. Thus, in *Le maître forgeron*, it begins: 'Combien de temps y a-t-il que nous n'avons pas reçu des nouvelles de St. Petersbourg ?' That is how it reads in the book, but on the stage it runs :

'KOn BiEn De TAn YA TIL Ke NOUs NA VOn PAs Re SU DEs NOU VEL De SEn PE TERS BOURg ?'

(For explanation of symbols see p. 271.)

The accent here will only come just before a pause; where the pause comes is dictated by the sense. Familiar conversation will make the pauses more frequent than in oratorical diction. The tonic accent may rise or fall or be level, but it falls at the end of a sentence.

If the speaker wishes to emphasize a word, this is done independent of the common tonic accent. *e.g.* 'C'est VOUS qui l'avez fait ?' 'Ce n'est PAS moi.'

It will now be advisable to deal with the vowel sounds in more detail.

In the first place, do not any longer call them 'ay,' 'ee,' 'owe,' 'you'; or, worst of all, 'aigh' or 'eye.' The very fact that they are so called in English implies a certain lawlessness and indifference to correctness, as well as being significant of the impurity and uncertainty of the English sounds. It must be remembered, in French, *a* is *a* (*cp. last*) and *o* is *o* (never as in *pop* or *moat*), and the same with all vowels. They have their distinctive sounds, and to give the wrong value to a French vowel is to play the wrong note. Now let us see what are these sounds. But it is necessary to say that each of the vowels have two forms, a *sharp* and a *flat* ('aigu' and 'grave'; or again, *shut*, 'fermé,' and *open*, 'ouvert').

'A'

'A,' as we have seen, is the typical open-mouthed sound with the mouth in its normal position. You can see the difference in 'A' flat and 'A' sharp if you compare the northern pronunciation of words such as *castle, pass, mass* with the southern. The northern is *castle* (KASSeL), with the 'A' as in *massive.* That is an English sharp 'A.' The southern sound is *castle* as if it rimed with *parcel.* That is the flat or open sound. Look in the glass as you say the two sounds, and you will see that the mouth opens more for the *parcel* 'A' than the *massive* 'A.' But in the French versions there are other things to take into account. In the flat sound the tongue must lie flat on the floor of the mouth. In the sharp sound the tongue is slightly arched, and touches the front upper side teeth, while *the lips are slightly drawn back* as for the beginning of a smile. The mouth is distinctly more open for the *flat* or *open* 'A' than for the *sharp* or *shut*. Examples:

Open A. â-me, â-ne, ma-le, bas, pas, passer.
Shut A. a-ni-mal, quatre, patte, matin.

'E'

This is the letter which English people pronounce worst. The reason is that, being the medium vowel, it lends itself to slurring and diphthongisation more than other vowels. Think of how many diphthongs in English have been reduced to an 'E': AY, EY, EIGH, AIGH, and 'A' itself if modified by a following silent 'E' (*made*). The English fault in pronouncing this vowel is the usual one. Either it is strangled at its birth, as in *pet*, where all three letters being run together the 'E' does not have room to live, or else it is continued while the mouth is taking up the position for the next letter; and as that position will probably be incompatible with the enunciation of a genuine 'E,' it becomes a diphthong. Thus 'mais' in an English mouth becomes *may* (*mei*), as can be tested if the sound is prolonged considerably.

There are at least three kinds of 'E's' to be considered: 'È' (or open), 'É' sharp (or closed), and 'E' sourd (or dull). For 'È' the mouth should be open enough to admit an ordinary lead-pencil; the tongue is in a similar position as for 'A' sharp; and, above all, the speaker must *keep the organs in the same position while the sound is going on.* If his mouth or tongue moves, he will himself hear a change in the sound, especially if he is prolonging the utterance.

Examples: MÊ, TÊ, DÊ, LÊ, KÊ, BÊ, VÊ, NÊ.

Note, 'Ê' is also represented by 'AI,' 'EI,' which in French are *not diphthongs.*

'É' sharp is formed with the mouth distinctly more closed. The space between the teeth should be wide enough to admit a half-crown (sideways). The tongue is more raised, so as to diminish the space along which the sound travels. The lips are slightly drawn back as in smiling. The *organs must be maintained in the same position.*

Examples: TÉ, SÉ, LÉ, NÉ, PÉ, MÉ; also represented -AI, -E(R).

'E' sourd (dull). This is the minimum genuine vowel. If a consonant be pronounced, and following it the sound be allowed to escape between the lips, rounded and somewhat advanced (as if one were sucking a pencil), the result will be the dull 'E.' Thus: Je, Me, Ne, Te, Se, Le.

If a genuine wholly-developed vowel sound is not produced, but only sufficient sound to produce the preceding consonant, then you have the minimum 'E' mute. This is usually ignored by phoneticians, but for an English speaker to do so brings on a considerable danger of pronouncing the consonant as an appendix to the preceding vowel, and so corrupting the latter. Moreover, this sound counts in verse and in music. In representations of popular speech the ignoring of it is marked by an apostrophe, as with us in the case of a dropped 'H.' Consequently beginners are recommended to give the sound some value, *except when it comes after a vowel* (as in 'venue') *or before a following one.* Thus the only difference between 'NU' and 'NUE' will be possibly a slight lengthening in the latter.

Examples: TÊTe, BÊTe, AISe, VASe, COMMe.[1]

'EU'

If Ê be shaped for, and then the lips are moved forward (without any movement in the jaw), the sound 'EU' will result.

If É be shaped for, and the lips then advanced, a softer version of 'EU' will be produced. These sounds have in French the spelling 'EU' ('ŒU' and 'Œ').

It will be noticed that these vowels are kindred sounds to 'E' sourd.

'O'

There are also two forms of 'O'—the 'O' in 'porte' and the 'O' in 'rose.' The former is the closed 'O,' the latter the open.

The distinctive position of the month for 'O' is the rounding of the lips. In the case of the closed 'O' the mouth is only slightly rounded; for the open 'O' it is rounded and protruded, the lips being thus brought together. In both cases the tongue is arched, more decidedly so in the case of closed 'O.'

The danger for an Englishman is to pronounce the open 'O' too short, as in *not.* It is necessary to dwell on the vowel long enough to really pronounce it. Thus: 'NO-Te.' One will notice a Frenchman speaking English make the reverse mistake: 'NO-ta Tall.'

Closed 'O' in English is in danger of being diphthongised. We say *rope, boat,* in the usual way, beginning the vowel as the mouth is opening, and continuing it as it closes, and consequently there creep in other sounds. This[1] is most marked in the Cockney 'NO' ('NAOW'). But the same tendency strikes one accustomed to the pure 'O' sound in the speech of those who would shudder to think that there was any resemblance in their diction to the Cockney.

'OU'

This vowel is habitually written in French with these two letters, but it is a single vowel. It is written in the phonetic alphabet as 'U,' but it is not pronounced as the English 'U' in *blue* or *new.* Being an 'U,' the space in the mouth is diminished by the tongue being well drawn back and arched. The lips are advanced so as to give a slight whizz to the sound, especially if it is being said with force: TOUt, TOUs, VOUs, NOUs.

Note that French comic papers make English people say 'VOO' for VOUs.'

'I'

This is the finest sound in our speech. Notice that we use it to imitate 'squeaking or whispering.' The French 'I' differs from the English in that it is produced with the tongue placed against the upper front teeth and leaving a narrow groove in the middle, along which channel, as through a pipe, this diminutive, high-pitched sound comes. The English 'I' is produced with the tongue further back against the hard palate, and in the case of words such as *it, pick, lit,* the contact is much shorter than in any French sound. Thus a Frenchman saying *It is indeed,* seems to us to say '*eet ees eended.*' The English make the opposite fault in 'il y vit.'

'U'

We saw that É and Ê had forms produced by advancing the lips ('EU' and 'EU'). The French 'U' is 'I' treated in the same way. In fact, this rule will give it: Shape for 'I,' mean to say 'I,' and then advance the lips. For practice it is well to say several times, 'I-U, I-U, I-U, I-U.'

Examples: MU, NU, LU, SU, VU, DU, BU.

[1] It is M. Passy who has banished 'E' mute from French, but as he occasionally gives it value in his phonetic script, and *then* the same value as in 'le,' 'me,' surely there is some ground for giving it that value whenever a word is mentioned by itself. M. Legouvé some years ago made a very spirited defence of 'E' mute in *Le Temps.*

[1] A Scotsman mimicking any Southerner will illustrate this. 'Aow. Do yeou think SaO?'

There remain to be considered three sounds: ' UI,' ' OI,' and ' GN ' (GNE).

' UI ' is found in ' huit,' *eight ;* ' Je SUIS,' ' LUI,' ' PUIS.' This is really the French ' U ' turned into a semi-consonant, as is ' Y ' with us ; but the mistake English people make is to shape for ' OU ' or an English ' U ' instead of for the French ' U.'

Thus we say ' OUI ' instead of ' UI.' The tongue, being in the position for our ' U,' leaves more space in the mouth than it should, and a ' W ' makes itself heard.

OI '

This is not a separate sound at all ; it is an ' A ' with a ' W ' in front, or, more strictly, with the French ' OU ' made into a semi-consonant and followed by ' A.' We are too apt to make the sound after the ' W ' rather an ' O ' than an ' A,' as in *what.*

' GN,' ' GNE,' ' IGN '

This is formed by lowering the velum as for a nasal, and checking the speech current by pressing the middle of the tongue against the hard palate, but keeping the tip of the tongue against the lower front teeth. Many French people, however, content themselves with uttering an ' N ' followed by a semi-consonantal ' I ' (or ' J ' : ' PA-Ni-ER,' ' O-Ni-ON,' or ' O-Nj-On '). A French ear will not be scandalised by a similar sound from a foreigner.

Consonants [1]

French consonants are more defined and more clearly uttered than the English. If they are pronounced slovenly they must have a bad effect on the vowels. Enounce the consonants, then, with emphasis, and avoid drawling or clipping. There are three consonants, however, to which special attention must be drawn : ' R,' ' L,' and ' L ' mouillé, as it is called.

' R '

It must be recognised, in the first place, that ' R,' properly speaking, does not exist in English. The trilled ' R ' is recognised in French, and the English learner must be careful to trill the ' R ' wherever he finds it, except in the termination *-er,* where it is mute (' premier,' ' parler '). English people must also be careful to pronounce ' R ' distinctly in places where it occurs in conjunction with another consonant. Thus in ' très ' the ' T ' and ' R ' must not be run so close together as in *tray,* but a slight separation made : ' T-REs.'

[1] Note that ' Ch ' in French never has the sound of ' TCH ' as in check, but a soft sound similar to that in ' SH ' (SHOULD).

So ' G ' is hard before ' A,' ' O,' ' U,' but soft before other vowels. The same with ' C,' unless ' C ' has a cedilla (ç), when it is soft even before ' A,' ' O,' or ' U.

In the French ' L ' the tongue must be in a much more horizontal position than in English, where it may come in contact with any part of the hard palate. A similar fault is common with ' I,' the vowel kindred to ' L.'

This brings us on to ' L' mouillé, or ' L ' following ' I ' or ' EI.'

When ' L ' or ' LLe ' is preceded by ' I,' the ' I ' is turned into a semi-consonant by pressing the tongue against the hard palate (where before it left a small space), and the breath, forcing its way through, produces a sound as in the English *Y-es.* When ' I ' occupies a subordinate position, as in ' BiEN,' ' DiEU,' the same sound is obtained.

The Nasalised Vowels

Every one is familiar with the fact that the French pronounce ' N ' (and ' M ') in an unusual manner. ' Up the Dong, certainemong nong,' is an effective caricature of the untaught Englishman's attempt to reproduce the effect. Although Montaigne writes ' ung ' for ' un,' this use has quite gone out in French. But how is this sound produced, and why does one say : ' bon,' but ' bo-nne ' ; ' un,' but ' u-ne ' ?

When a vowel is followed by an ' N ' or ' M,' and there is no immediate following consonant, that ' N ' or ' M ' is not separately pronounced, but the vowel itself is given a certain *resonance.* It is then said to be *nasalised.* This is done by placing the tongue-tip against the lower teeth and lowering the velum (or ' pin of the throat '). This adds the nasal cavity to the space in which the vowel is resonated, and the effect is to ' nasalise ' the vowel.

If a vowel follows the ' N ' or ' M,' then in the usual way that vowel forms a syllable with the consonant preceding it, and so the previous vowel, being robbed of its nasal letter, loses its nasal force.

There are four nasal sounds :

' AN,' spelt *an, am, en, em.*
' EN,' spelt *-in, -ein, -aim, -ain, (i)en.* (' I ' cannot be nasalised.)
' ON,' spelt *-on, -om.*
' ŒN,' spelt *un.* (' U ' cannot be nasalised.)

Examples :—[I here use capitals for fully pronounced letters, small *n* = *n* nasalised.]

' An.' Dans, DAn ; temps, TAn ; grand, GRAn ; sang, SAn.

' EN.' Pin, PEn ; pain, PEn ; sain, SEn ; faim, FEn ; impossible, InPOSSIBLe ; bien, BiEn ; Amiens, AMiEn. (Note, in ' pin,' ' brin,' etc., it is an ' E,' not an ' I,' which is really pronounced.

' ON.' Son, SOn ; mon, MOn ; nom, NOn ; non, NOn.

' ŒN.' Un, Œn ; brun, BRŒn.

Note that ' M ' and ' N ' nasalised are identical. Remember that, as ' Un ' is really ' Œn '

phonetically or by pronunciation, the lips must shape for 'Œ'—*i.e.* be advanced.

To avoid the ordinary English attempt at the nasal, do not let the tongue come in contact with the upper teeth as for the English 'N,' nor let the velum come in actual contact with the tongue. If you do either of these things, you will stop the breath and so *must* produce a consonant ('N' in the first case, 'NG' in the second). Take care, when a nasal is in the middle of a word, not to pronounce the 'N' after having nasalised the vowel. Thus: AnFAn, not AN-FAN; TAnTe, not TAN-Te.

Here are instances of nasals and non-nasals: innocent, I-NO-SAn; inutile, I-NU-TI-Le; incredule, In-CRE-DU-Le; imbecile, In-BE-CI-Le; BOn, but BO-Ne; brun, BROEn, but brune, BRU-Ne.

The reason for this non-nasalisation is simply this: the 'N' is required for the following syllable in accordance with the ordinary law, and so does not attach itself to the preceding vowel. 'I-NU-TI-Le,' 'BO-Ne,' are the ordinary way of dividing a word into syllables.

Below is 'Les Djinns' in a modified phonetic. The following principles are to be observed:

Tonic accent on last syllable of line. Syllables to be divided, where possible, consonant + vowel.

Consonants unpronounced are omitted. A small 'n' indicates nasalisation.

The vowel characters used are those of which the sound has been explained. ('U,' 'OU,' 'UI' = French sounds so written: 'WA' = French 'OI.') Open vowels marked with grave accent, closed vowels with acute. Small 'e' = 'E' sound: 'e' written above the line is merely the means of pronouncing the previous consonant.

Where a division is made in a line, an upward tonic accent to be made.

3. LÁ RU MÈUR Á PRÓ CHe
LÉ KO LÁ Re DI
SÈ KÓ Me LA KLÓ CHe
DŒn KOU VAn MO DI
SÈ KÓ MŒn BRUI De FOU Le
KI TO NÉ KI ROU Le
É TAn TO||SÉ KROU Le
É TAn TO||GRAn DI

4. SÈ LÉ SEn||DÉ ZIN KI PÀSe
É KI TOUR BI YO N En SI FLAn
LÉ ZIF||Ke LÈUR VÓL FRA KÀ Se
KRÁ Ke KÓ M||Œn PEn BRU LAn
LÉUR TROU PO LOUR||É RÁ PI De
VÓ LAn DAn LÉ SPÀ Se VI De
SAn BLŒn NU ÁGe LI VI De
KI PÓR TŒn É KLÈR||O FROn

5. KRI De LAn FER VWA KI UR LÉ KI PLÈU Re
LÓ RI BLÉ SEn POU SÉ PÀR LÁ KI LOn
SAn DOU Te O StEL SÁ BÀ SUR MA De MEURe
Le MUR FLÉ CHI SOUn Le NWAR BÁ TÀ YOn
LA MÈ ZOn KRI É CHAn SÉLe PAn CHÈ
É LOn DI RÉ Ke DU SÓL Á RÁ CHÉ
En SI KIL CHÀ SU Ne FEU YE SÉ CHÉ
Le VAn LA ROU LÁVEC LÈUR TOUR BI YON

6. IL SÓn PÁ SÉ||LÈUR KO ÓRTe
SAn VÓ LÉ FUI||É LÈUR PI É
SÈ Se De BÁ TRÁ MÁ PÓRTe
De LÈUR KOU||MUL TI PLI É
LÉ RÈ PLEn||DŒn BRUI De CHÈ Ne
É DAn TOU LÈ FÓ RÈ PRÓ CHÈ Ne
FRI SÓ Ne TOU LÈ GRAn CHÈ Ne
SOU LÈUR VOL||De FEU PLI É

(For other verses see p. 240).

COURSE OF READING

To mention a few useful grammars, there are Atkins' *Skeleton Grammar* (Blackie), an almost irreducible minimum; Siepmann's *French Grammar*, a wonderful piece of compression, published by Macmillan; and a larger work, Brachet's *French Grammar* (Hachette). Professor Spiers' *French Drill* will be found very handy and useful, as will also his vocabularies.

Two useful dictionaries are Cassells' (3*s*. 6*d*.) and Gasc's (Bell & Co., 3*s*. 6*d*.).

For French authors, Dent ('Everyman') and Nelsons' are now issuing attractive French collections, while Hachette have cheap editions of all French classics.

Here is a suggested course of French reading graduated to suit beginners. These should present little difficulty after this book has been *mastered*. Daudet, *La Dernière Classe;* Hugo, *Poems, Le Bourgeois Gentilhomme;* selections from Michelet, *Jeanne d'Arc* (Blackie's 'Little French Classics,' 4*d*. each). Siepmann's *Tartarin* is an abridgement of a famous work (Macmillan 2*s*.). *Marie Claire* (Margaret Adoux) is a masterpiece written in a wonderfully simple style. *Le Champi* (George Sand), and *Fadette*, by the same author, will be appreciated by all with a taste for good things. Any of the comedies of Labiche are laughable, and Musset's little comedies (*On ne bandine pas avec l'amour, Il ne faut jurer de rien, La coupe et les lèvres, On ne saurait penser à tout*) have an undying charm. *Le livre de mon ami, Cranquebille, L'euti de Nacre,* and *Le Crime de Sylvestre Bonnard,* are good samples of the clearness and ironic charm of Anatole France. *Colomba* (Merimée) is an interesting book of the 'Carmen' style, *Maupassant* ('Edition de la jeunesse') is the best possible French reading. *The Three Musketeers* and *Chicot* (Dumas) are too well known to need more than mention.

In poetry, Hugo is of course the favourite with foreigners, but Musset, Chénier, Boileau, La Fontaine, Racine, Molière, and Corneille, given a chance, will gradually assert their empire.

Three poetic collections may be mentioned: *The Oxford Book of French Verse*, Nelsons', Gowans and Gray's. A good selection of nineteenth-century poetry is that of Henri Sensine (Pagot et Cie.).

W. CONACHER, B.A.

FRENCH LITERATURE

A. Origins to Renaissance.—French literature dates from the eleventh century. Until that time, the lack of political unity in France and the resulting want of a national language, had prevented the production of literary works of any real value. From the end of the ninth century, the dialect of the Ile de France gained steadily in importance, and became in the twelfth century the literary language of the whole country. The same period marks the first flowering time of the national genius. The mass of semi-historic, semi-legendary lore, that had been accumulating since the earliest times, crystallised in the eleventh and twelfth centuries around the persons of certain heroes, such as Arthur, Charlemagne, and Alexander the Great. Each hero became the centre of a cycle of epic poems, composed by different poets, who adapted their material to suit their particular requirements. The literary value of these productions is, with the exception of the *Chanson de Roland* and the works of Chrétien de Troyes, very small; their historic value is great. They mirror, more faithfully and clearly than any chronicle, the times in which they were written.

By the middle of the thirteenth century the epic vein had run dry; the public preferred to be amused by farces and satires, or to be morally instructed by allegories, rather than to have its imagination stirred by the recital of glowing deeds. French prose, hitherto eclipsed by Latin, began to constitute itself, in the historical works of Villehardouin and Joinville in the thirteenth, Froissart in the fourteenth, and Philip de Commynes in the fifteenth centuries. With the exception of these authors and of one poet, François Villon, no French writer of any distinction appears during the Middle Ages. The cause of this decadence seems to be mainly in the general disintegration of social and political institutions that was taking place during this period of European history. The dawn of modern civilisation came, towards the end of the fifteenth century, bringing in its wake a new intellectual and æsthetic outlook. The Italian Renaissance gave France the feeling for art; the Reformation awoke in her a desire for independence and freedom. These two influences, combined, caused the birth of modern French literature.

B. The Renaissance.—The problem that presented itself to the authors of the sixteenth century was how to evolve, from the material at their disposal, a national literature worthy to rank with that of Greece and Italy. There, on the one hand, were the classic masterpieces; on the other, the French language, unwieldy, poor in vocabulary, incapable of expressing fine emotions and lofty thoughts, and the French literature, practically non-existent, certainly offering no models worthy of imitation. The great work of the sixteenth century was, in spite of many errors, to place the language on a sure foundation, giving it amplitude and richness, and making it capable of being a channel for transmitting artistic emotion and intellectual thought. This task was accomplished partly by grammarians, partly by poets. The principles which guided the reformers are summed up in the *Défence et illustration de la langue française* (Joachim du Bellay). "Imitate the best Greek and Latin authors," is the gist of his remarks. "Live with them—soak yourself in them—make them bone of your bone and flesh of your flesh. And then produce the same forms of literature as they did in your own mother-tongue."

The result was not entirely satisfactory, and much of the work done by du Bellay and his like had to be undone. But on the whole, it is impossible to over-estimate the usefulness of their labours. They introduced all the classical poetic forms and metres; and one or two of the school, who were poets rather than grammarians, left as a legacy to succeeding generations poems worthy to rank with the best that are to be found in French literature.

Towards the end of the century, two writers, Montaigne and Amyot, produced works that are a landmark in the history of French prose. It only required a certain amount of pruning and weeding out for the French language to become a perfect instrument for the production of works of genius. This process took place between 1595 and 1615.

C. Transition to Classicism.—The transformation of the Renaissance spirit into the spirit of classicism took place during a period of about twenty years. The religious and political disturbances of the sixteenth century gave place in the seventeenth to a state of calm and order which was reflected in the literature of the period. The transition from the writings of Montaigne and Ronsard to those of Descartes, Malherbe, and Pascal was effected during the reign of Henry IV and the beginning of Louis XIII's. The importance of restraint and discipline in art was realised for the first time by Henri Balzac in prose, by Régnier and Malherbe in poetry. The latter, gifted with small poetic imagination but with a keen sense of form, paved the way for the great classic poets, Racine and Boileau. "Enfin Malherbe vint, et le premier en France, fit sentir dans les vers une juste cadence" (Boileau, *L'Art Poétique*).

The drama, which had been in the sixteenth century either purely literary and erudite or

coarse and vulgar, was placed on a new footing by Alexandre Hardy. Possessed of little literary ability, but great dramatic insight, he laid the foundations of the national drama of the seventeenth century.

D. The Age of Classicism.—The French classical period is usually regarded as the greatest in France's literary history. Never before or after the seventeenth century have so many men of genius arisen simultaneously, and never has the general standard of the work produced throughout the period been so high. This is largely due to the political and social conditions of Louis XIV's reign, which must be studied in order to appreciate the literature at its true value. Society—the society of the Court and the lesser aristocracy—played an extraordinarily important part in the determination of literary genres and style. Æsthetic problems were discussed and resolved in the Parisian salons; an Academy, protected by the Prime Minister, was established to draw up literary and grammatical rules and to compile a dictionary of the language. Thus the individual author was obliged to conform to a central authority, and express his personal conception in a form that would appeal to the general body of his contemporaries, all of whom were guided by the same canons of taste. The natural result was to suppress lyricism and to foster such branches of literature as the drama, eloquence, moral and philosophical essays, letters, and memoirs.

The tendency to draw up codes and formulate rules in literature was strengthened by the Cartesian philosophy, whose main doctrine was: "Ne recevoir jamais aucune chose pour vraie que je ne la connusse évidemment être telle" (Descartes, *Disc. de la Méthode*). The method of critical analysis, of submitting every proposition to the test of the reason, was applied consciously and unconsciously by the writers of the seventeenth century. "Aimez donc la raison" is the constant exhortation of Boileau, the critic and æsthetician of the period. The whole-hearted admiration of the classics, which the sixteenth century had left as a legacy to the succeeding age, was regulated and held in check by this unshakable belief in the reason of man. Why are the classics to be imitated? Because our reason tells us that they are true to nature, and truth to nature is essential for the production of works of beauty. By "nature" the seventeenth century meant all that is permanent, typical, normal in the universe. The passing phenomena of the natural world—the individual, eccentric, abnormal—do not belong to the domain of art.

The theories of the classical age may be found in Boileau's *Art Poetique*, and in certain of the prefaces to the plays of Molière, Corneille, and Racine. These theories led in practice to the production of works whose characteristics were balance, harmony, clearness, and naturalness. The temporary aberrations that had spoilt the literature of the first half of the century—preciosity, love of the burlesque and extravagant, imitation of Spanish bombast and Italian "concetti"—were entirely overcome as time went on. From 1660 to 1690 an even standard of excellence was maintained, and one masterpiece after another produced.

E. The Age of Rationalism (eighteenth century).—A change took place towards the end of the century. As the men of genius disappeared one by one, and no others took their place, the fine artistic perception and pure taste, that had distinguished the literary public of the Grand Siècle, were gradually blunted and coarsened. The Cartesian spirit of inquiry continued to hold sway, and little by little it invaded the domain of feeling as well as that of thought. The æsthetic enjoyment of a work of art was stifled by too great an anxiety to examine its composition. Discussion arose as to why the classics were to be admired and studied by the moderns; and since the instinctive appreciation had been lost, no satisfactory answer could be found. The *Querelle des Anciens et des Modernes* forms a bridge between the seventeenth century (æsthetic primarily and rationalistic secondarily) and the eighteenth century (rationalistic primarily, æsthetic hardly at all).

Two currents can be traced in the literature of the eighteenth century: one endeavours to continue the traditions of the preceding age, but with no comprehension of the principles that gave rise to those traditions. The other, and stronger current, rejects all tradition and authority, and relies on the power of intellect and reason to open new doors in every direction. Whenever writers followed the first current, they produced nothing of originality or interest. When they followed the second, they abandoned the domain of pure art and entered that of sociology, philosophy, or science. The great names of the century are those of Voltaire, Beaumarchais, Montesquieu, Diderot, Condorcet, Rousseau, Buffon—and the works that made them famous are philosophic letters, comedies of social and political satire, treatises on political economy and the philosophy of history, studies in natural history, science, and sociology. Thus literature had become a channel for the transmission of doctrines and ideas. In one case only do we find an intensely poetic nature, whose primary object in writing is to ease his overcharged imagination. The exception is Rousseau, a Swiss by birth, who lived an outcast from the society of his day, and who belongs in his literary tendencies to the nineteenth rather than to the eighteenth century. His chief disciple, Bernardin de Saint Pierre, has far more in common with his contemporaries than has his master. He borrows from Rousseau the love of external nature, untouched by the hand of civilisation, but there is something

artificial about the sentiment of *Paul and Virginie* that separates it from the writings of the Romanticists, to whom Rousseau undoubtedly belongs.

F. The Romantic Age.—The French Revolution put an end, for a time, to all literary activity, except of the sort that could be used as a weapon in the great combat. Then came the Empire, with the iron hand of Napoleon weighing heavily on any attempt at individualism, whether in politics or art. Eighteenth century influences continued to work, and literature continued to suffer from an excess of intellectuality. Soon, however, a fresh impetus was given to men of letters by the philosophical teaching of Victor Cousin and his school. The eighteenth century philosophers had regarded man as a product of external influences. His thoughts and sentiments were determined by the material conditions of his life, and his intellect was merely the record of his sensations. Victor Cousin, combining the ideas of his masters, Royer Collard and Laromiguière, with the doctrines of the great German philosophers, Kant, Hegel, and Schelling, affirmed the existence of a spontaneous, free principle of life, working in man and producing all the highest manifestations of human activity. Here was a conception that could inspire and stimulate the imagination, as the materialism of the previous century had failed to do. The generation born of the Revolution, and coming to manhood just as the new doctrines were taking root, turned its back on all that had gone before, and set itself to create a new æsthetic ideal. This ideal was embodied in the writings of the Romantic School. From 1820 to 1830 poetry awoke and triumphed on all sides. Man recognised himself once more as a spiritual being, bound by a mysterious bond to the invisible, eternal universe. He no longer looked on emotion as a result of certain physical causes, to be analysed and described in scientific terms. He was transfixed in awe and delight at the beauty of his own nature and of all creation; and he felt the imperative necessity of expressing his feeling in song. Lyricism was born for the second time; it had been dead since the sixteenth century. History, and literary criticism were transformed, now that they were regarded as a means of tracing, for the benefit of present and future generations, the action of that mysterious force which works through man yet independently of man. The danger of this new attitude of mind was that it tempted men to live too much in the subjective world of thought and feeling. This is proved by the fact that the drama and the novel, the most objective forms of literature, did not make much progress during the Romantic outburst. They came into their heritage in the next period—the reaction to realism and positivism.

G. Realistic Reaction.—During the Second Empire, literary inspiration was sought not in the soul of the writer, but in the objective world around him. The novelist and dramatist endeavoured to correct the vices and weaknesses of society by depicting characters and situations that corresponded in every detail with their living counterparts. The poets of the day, less richly endowed in feeling and imagination than the Romanticists, turned their attention to the perfection of form. They wrote little, but polished all their work as highly as possible. The heat had been lost—but the brilliance was perhaps greater than in the days of Lamartine, Musset, and Vigny. On the whole, the atmosphere of the Second Empire was not favourable to art. The public preferred to be amused rather than elevated, and its real interests were in the world of politics and commerce. Not until the last decade of the century did the ideal begin to reassert its claim over the real.

H. The Contemporaries.—Idealism, in the form of devotion to a Cause, a Religion, or Humanity in general, is the prevailing note in every branch of literature at the present day.

The dilettantism and intellectual aristocracy of a Renan and his disciples have been replaced by an ardent desire to take an active part in the affairs of the nation. The man of letters is also the social reformer; he no longer considers that "tout contact avec la réalité souille un peu" (Renan). In other words, the individualism of the nineteenth century is gradually being transformed into a higher collectivism, where the individual realises the debt he owes and the responsibility he bears to humanity at large. The philosophy of such men as Bergson and Bontroux is fostering in Frenchmen the desire to penetrate into the spiritual and psychic world, to understand its laws and principles, and to interpret by them the phenomena of the material universe. For the first time in modern French literature, we have mystical plays and poems, revealing the deepest spiritual understanding. And the very men who produce such work have devoted their whole energy to the present needs of their country. Charles Péguy, author of the *Mystères de Jeanne d'Arc*, died on the battle-field. Maurice Barrès and Maeterlinck are employing their literary talent in the service of the French nation. One of the greatest of French literary critics, Emile Faguet, has recently brought out a book which condemns certain characteristics of his countrymen and exhorts them to greater perseverance, stability, and decision of mind. He detects in the nation as a whole a dislike of responsibility which, if indulged in too much, must prove fatal. This may be true of the masses, but the opposite must be affirmed of the educated classes, who are realising more strongly every day the necessity of occupying themselves with the social, moral, and intellectual welfare of the nation.

COURSE OF READING

I. **Bibliographies.**—Thieme, *Guide Bibliographique* (1800–1907).—Lanson, *Manuel Bibliographique* (1500–1900).

II. **General History and Criticism.**—Lanson, *Histoire de la littérature française* (11th edition, 1909). A standard work, suggestive, stimulating, and providing in the footnotes an excellent bibliography.—Doumic, *Histoire de la littérature française.* A short, concise survey. Useful for examination, or as a first introduction to the subject.—Brunetière, *Etudes critiques ; Nouvelles études ; Les époques du théâtre français.* Miscellaneous essays dealing with a wide variety of literary questions. Everything written by Brunetière is of the highest value.—Faguet, *Études littéraires sur le* 16^{me}, 17^{me}, 18^{me}, 19^{me} *siècles ; Drame ancien, drame moderne ; Politiques et moralistes du* 19^{e} *siècle.*—Dowden, *History of French Literature.*

Pre-Renaissance.—Gaston Paris, *Tableau de la littérature française au moyen-âge.*

Renaissance, Sixteenth Century.—Tilley, *History of the French Renaissance.*—Sainte-Beuve, *Tableau de la poésie française au XVI*^{e} *siècle.* Short, but interesting, as showing the link between the Romanticists and sixteenth century poets.

Classical Age, Seventeenth Century.—Tilley, *Montaigne to Molière.*—V. Cousin, *Madame de Sablé ; La jeunesse de M*^{me} *de Longueville.* Excellent studies of Society in the seventeenth century.—Mary Duclaux, *The French Ideal.* Studies of Pascal and Fénélon as representatives of French thought. Penetrating and original.—Strowski, *Pascal,* 3 vols. The best treatment of Pascal and the evolution of religious thought in France in the sixteenth and seventeenth centuries.

Eighteenth Century.—Le Breton, *Le Roman au* 18^{me} *siècle.*—Lanson, *Nivelle de la Chaussée et la comédie larmoyante.*—Morley, *Voltaire ; Rousseau ; Diderot.* Somewhat heavy, but very sound, and giving a good general outlook.—Brunetière, *Le roman naturaliste.*

Nineteenth Century.—Strowski, *Tableau de la littérature française au* 19^{me} *siècle.* The only good general study of the nineteenth century. Full of illuminating ideas.—Brunetière, *L'évolution de la poésie lyrique au* 19^{me} *siècle.*—Paul Bourget, *Essais de psychologie contemporaine.*—Pierre Lasserre, *Le Romantisme français.* An amusing diatribe against the Romantic school. Exaggerated but interesting.—Jules Lemaître, *Les Contemporains ; Impressions de théâtre.* Spicy in matter and polished in style, but not always reliable.

III. **Special Criticism.**—Individual authors should be read, when possible, in the collection *Les Grands écrivains de la France.* The biographies and notes in this series are quite excellent. Studies by eminent men of most of the great writers exist in the series *Grands écrivains français.* The names of Brunetière, Lanson, Faguet, Strowski, Paul Stapfer stand out pre-eminent among contemporary critics and may always be consulted with advantage. Sainte-Beuve and Taine are the great literary authorities of the nineteenth century.

IV. **Anthologies and Collections.**—Constans, *Chrestomathie de l'ancien français monmerqué—Le théâtre français au moyen-âge.* With modern French versions.—Péllissier, *Anthologie des poètes français du XVI*^{e} *siècle*—Lucas, *Oxford Book of French Verse* (thirteenth to nineteenth century). *Anthologie des poètes nouveaux.* Published by Figuière, Paris. Containing the writings of the Unanimistes and other contemporary poets.—Lanson, *Choix de lettres du XVII*^{e} *siècle.*—Saintsbury, *Specimens of French Literature* (fifteenth to nineteenth century).

V. **Representative French Writers; and their Chief Works.** (*Renaissance*).—Clément Marot (1497–1544), *Epitres. Psaumes.*—Ronsard (1524–1585), *Sonnets.*—Rabelais (1495–1553 c.), *Gargantua.*—Montaigne (1553–1592), *Essais.*

Classical.—Corneille (1606–1684), *Le Cid ; Polyeucte ; Horace.*—Racine (1639–1699), *Andromaque ; Phèdre ; Esther.*—Molière (1621–1673), *Les Femmes savantes ; L'Avare; Tartuffe; Le Misanthrope.*—La Fontaine (1621–1695), *Fables.*—Boileau-Despréaux (1636–1711), *L'Art Poétique Satires II, IX, Epitres VIII, IX.*—Descartes (1596–1650), *Discours de la Méthode.*—Bossuet (1627–1704), *Oraisons funèbres.*—Fénelon (1651–1715), *Télémaque ; Lettres spirituelles.*—La Rochefoucauld (1613–1680), *Maximes.*—Pascal, (1623–1663), *Lettres Provinciales ; Pensées.*—Madame de Sévigné (1626–1696), *Lettres.*—Madame de Lafayette (1634–1693), *La Princesse de Clèves* (novel).—La Bruyère (1645–1696), *Caractères.*

Eighteenth Century.—Montesquieu (1687–1755) *Lettres Persanes ; L'esprit des lois.*—Le Sage (1668–1747), *Gil Blas* (novel).—Voltaire (1694–1778), *Lettres anglaises ; Candide* (story); *Mérope, Zaire* (dramas); *Siècle de Louis XIV* (history).—Diderot (1713–1784), *Paradoxe sur le comédien* (æsthetics); *Lettre sur les aveugles* (philosophy); *Le père de famille* (drama).—Buffon (1707–1788), *Histoire Naturelle.*—Rousseau (1712–1778), *La Nouvelle Héloise* (novel); *Le Contrat social* (sociology); *Confessions.*—Marivaux (1688–1763), *Marianne* (novel); *Le jeu de l'amour et du hasard* (comedy).—Beaumarchais (1732–1799), *Le mariage de Figaro, Le barbier de Séville.*—André Chénier (1762–1794), *Iambes, Eglogues.*—Bernardin de St. Pierre (1737–1814), *Paul et Virginie.*

Nineteenth Century.—Madame de Staël (1766–1816), *De l'Allemagne.*—Chateaubriand (1768–1848), *Génie du Christianisme.*

Poets.—Lamartine (1790–1869), *Méditations :*

Harmonies : Jocelyn.—Alfred de Vigny (1797–1863), *Poèmes antiques et modernes.*—Victor Hugo (1803–1885), *Feuilles d'Automne ; La légende des siècles* (poetry) ; *Les misérables* (novel) ; *Hernani* (drama).—Alfred de Musset (1810–1857), *Les Nuits ; Rolla* (poem) ; *Lorenzaccio, On ne badine pas avec l'amour* (plays).—Theophile Gautier (1811–1872), *Émaux et camées.*—Leconte de Lisle (1820–1894), *Poèmes.*—Verlaine (1844–1896), *Poèmes.*

Critics and Historians.—Sainte-Beuve (1804–1869), *Causeries du Lundi ; Port Royal.*—Taine (1828–1893), *Histoire de la littérature anglaise.*—Renan (1823–1892), *Souvenirs d'Enfance et de jeunesse ; Études de morale et d'histoire ; Vie de Jésus.*

Novelists.—George Sand (1804–1876), *Consuelo ; La Mare au diable.*—Stendhal (1783–1842), *Le Rouge et le Noir.*—Balzac (1799–1850), *Le père Goriot ; Eugénie Grandet ; Seraphita.*—Flaubert (1821–1880), *Madame Bovary : Salammbô.*—Zola (1840–1902), *L'Assommoir ; Germinal.*—Daudet (1840–1897), *Fromont jeune et Risler aîné ; les Rois en exil.*—de Maupassant (1850–1893), *Pierre et Jean ; Contes.*

Dramatists.—Alexandre Dumas (1824–1896), *La Dame aux camélias ; le Demi-monde.*—Emil Augier (1820–1889), *Le gendre de M. Poirier.*—Henri Becque (1837–1899), *Les Corbeaux.*—Péguy (–1915), *Mystères de Jeanne d'Arc.*

Contemporaries. *Poets.*—Paul Claudel, *Cinq grandes odes ; L'Annonce faite à Marie ; l'Otage*—Vildrac, *Livre d'Amour.*—Henri de Régnier.—Francis Jammes, &c.

Dramatists.—Paul Hervieu, *La Vierge Folle ; le Dédale.*—Brieux, *La Robe rouge.*—Rostand, *L'Aiglon ; Cyrano de Bergerac,* &c.—Anatole France, *Le crime de Sylvestre Bonnard.*—Paul Bourget, *L'Etape, Le Disciple.*—René Bazin, *La Terre qui meurt.*—Romain-Rolland, *Jean-Christophe,* &c.

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THE ITALIAN LANGUAGE AND LITERATURE

I

ORIGIN OF THE ITALIAN LANGUAGE

The origin of the Italian language is to be traced to the numerous invasions of Italy by the barbarians, who caused the fall of the Roman Empire. The Low Latin then spoken in the Peninsula was still further spoiled by the ignorance of the invaders and by the complete oppression which the natives were subjected to, and which destroyed all learning in all the different social classes of the community. The intermingling of so many different dialects of barbarians, belonging to so many different tribes and races, with the dialects spoken at that time in Italy, was a very long process, which lasted about a thousand years—those thousand years which are known as the Dark Ages, when illiteracy was universal, even reading and writing being confined to a few monks or priests, and when even kings were unable to write or read. A patient and persevering historian, Muratori, has been able to follow the track of this gradual transformation of the Latin into the Italian language by recording it in his voluminous collection of inscriptions on the tombstones and in the churches of the different provinces of Italy during the Dark Ages. In this useful book we can find hundreds of words, now belonging to the Italian language, which were engraved during the early centuries of the Christian era. It was, however, only towards the end of the eleventh century that we can recognise the real beginnings of the new language of Italy.

The growing power on the sea of the republics of Amalfi (where the marine compass was invented), of Genoa, of Pisa, and of Venice had greatly contributed to the awakening of some of the most industrious of the Italian towns. Their commerce with the Mediterranean ports brought them a wealth which increased their power. Then came the Crusades, which further contributed to their expansion; and as most of the Crusaders had to go to the East by way of Italy, this country reaped a great harvest of money and of whatever knowledge the best men of foreign lands possessed. On their way to Palestine, or on their return from the Holy Land, the Crusaders dallied in Italy to pay a visit to Rome. Some were murdered there, like the Earl of Cornwall; others became leaders of mercenary troops, like Sir John Ackwood (L' Acuto), who served the Republic of Florence and was buried in Santa Croce, where, as in Westminster Abbey, the most famous Italians are buried.

Its Earliest Writers.—San Colombano, an Irish monk, who came to Italy towards the end of the sixth century, founded a monastery at Bobbio, and collected in its library some interesting MSS., only lately discovered there.

An Englishman, Keen, or Queen, better known under his Italian name of Alcuino (726–804), who was one of Charlemagne's most confidential advisers, founded a literary academy in Italy, which among its members included the emperor himself and several of his knights. We find other dim traces of learning through San Pier Damiano (988–1072), Lanfranco (1005–1089), San Anselmo d' Aosta (1033–1109), and Pope Alexander III, famous for having in Venice, in 1177, put his foot on the neck of a German emperor, when the latter was forced to sue for peace by the victorious Italian cities. Thus after one hundred years was repeated the shame of Canossa, where another German emperor was obliged to pass three days and three nights outside the castle of Canossa, fasting and begging another Pope's pardon, only obtained under the most dishonourable conditions.

As early as the year 1089 we find Lanfranc Archbishop of Pavia, writing letters in Italian, and Anselm, Archbishop of Canterbury and an Italian, following his example. Pier Lombardo, Archbishop of Paris in 1164, and the Viscount de Hautefort, a Provençal troubadour, both wrote in Italian some of their letters. The latter was a favourite of King Henry of England and of his son. There is from his pen a "Song against Peace," of such power as to entitle him to be called the Kipling of the twelfth century. In his old age he retired to the monastery of Dalon, where he died in 1207. Laurens calls him "Le Tyrtèe du Moyen Age."

Folquet of Marseilles, another Provençal poet, became in later life a bishop and a merciless Inquisitor, who enjoys the infamous notoriety of having destroyed the Albigenses with blood and iron, in his struggle against heresy. Another centre of reformers of the Roman Church was uprooted in Brescia, where the saintly Arnaldo was burned at the stake in 1154.

Wherever in Italy a revival of learning took place, there also rose religious reformers; but these were everywhere unsuccessful against the mighty power of the Popes of that time. To make a stand against the doctrines of Reformation in the Church, Francis of Assisi founded a monastic order, which gained overwhelming power over the minds of the ignorant Italians. The humble life of their founder gained for his followers a popularity hardly justified by their actions, which were mercilessly satirised in immortal *novelle* by the Italian *novellieri* of all the following ages. He left some writings in uncouth and illiterate Italian, that by his followers were called "poetical," and which, owing to religious bias, have secured a reputation to which they are by no means entitled. In the same century another order of monks was founded, the Dominican, which became equally popular among the Italian masses.

It would be impossible to fix a single date, or a single locality, where the Italian language was born. There were, more or less, in most Italian centres of life, men whose early efforts at the poetical expression of their feelings were only endeavours to convey them to the ladies they loved. It was love, the natural passion of life, which had to be revealed to women, who had become utterly ignorant of the Latin language, and who only knew what was so correctly called the *volgare*, the speech of the common people. This *volgare* became, therefore, the best means of communicating with one another, and of expressing oneself with some assurance of being understood. The Latin had been completely forgotten by the majority of the population, and its knowledge was limited to monks, priests, lawyers, and doctors.

As the passion of love is best expressed in poetry, poets were first in the field to make use of the new language understood by the people. But love has no particular residence in any region or town, and so it happened that love poetry was written almost everywhere in Italy. There were places where, owing to a powerful Court, or to a better-gifted writer, a more detailed record was kept of the earliest writers of that locality; and in so far we can say that at such places the first dawnings of the Italian language are to be traced. One of such places was the Court of the Emperor Frederick II in Sicily, who was himself a minor poet. The best-known men of his age, of different nationalities, flocked to his Court, where they were warmly welcomed and liberally rewarded. Even from Scotland writers travelled to Sicily to visit the Court of Frederick. Sir Michael Scott, the author of *De Secretis Naturæ*, went there, where he was lavishly rewarded for his long journey; and this, later on, may have consoled him for his unpopularity with the vulgar, who believed him a magician—a belief which in those superstitious times was equal to a sentence of death. Sir Walter Scott, a more illustrious member of that ilk, mentions the fact in his *Ivanhoe*.

To mention the names of all the minor poets, who swarmed everywhere in Italy during the earlier years of the thirteenth century, would be a useless and thankless task, their writings hardly deserving the name of poetry. Their names are only recorded to show the slow and gradual progress of the language. Among them were Guittone d' Arezzo, the author of a canzone on the battle of Montaperti; Guido Guinicelli, a native of Bologna, highly praised by Dante; Guido Cavalcanti, to whom Dante addressed a well-known sonnet; and Dino Frescobaldi.

II

THE GRAMMAR OF THE ITALIAN LANGUAGE

Having so far given a general idea of the many causes and the numerous men who contributed to the transformation of the Latin into the Italian language, we will now endeavour to describe the main peculiarities that make the latter the most perfect and at the same time the simplest of all modern languages.

The letter *h* not having any individual value in the Italian alphabet—it is used only to harden the sound of the letters *c* and *g* before *e* or *i*, or to distinguish the different meanings of 'ho, hai, ha, hanno'—we find that with only twenty letters the Italian alphabet can form all the words necessary to convey all possible thoughts to every Italian. Of a thing worth nothing at all, the Italians say that 'non vale un' acca,' *is not worth an* '*h*.'

All its letters have a single and invariable sound, never modified either by the use of the accent or by any grouping of letters, except in the case of the *gn*, which conveys a faint sound of *i* before the following vowel, and in the syllable *gli*, which has a liquid sound.

There is in Italian only one accent, from left to right; and it is not used for any variation or modification of sound, but only to denote the different meanings of a word or the loss of a final syllable. The apostrophe denotes the loss of a final vowel.

All Italian words, with few and unimportant exceptions, end with a vowel.

The sibilant letter *s* is never found between two consonants. The only words in which the letter *s* is found between two consonants are the following: conscio, *conscious*; constare, *to result*; constatare, *to prove*; inscrutabile, *inscrutable*; insperato, *unhoped for*; instabile, *unstable*; instare, *to insist*. These exceptions are due to the fact that, if the consonant preceding the *s* were dropped, the word would have a different meaning.

The five vowels are pronounced in complete accord with the natural formation of the glottis. The letter *a* can only be sounded with the throat wide open, whilst the sound of the other four vowels is obtained by closing it gradually, as in the following:

a in the English word *father*.
e " " *bet*.
i " " *bit*.
o " " *not*.
u as the *oo* in the English word *boot*.

As for what grammarians call the double sound of the *e* and *o*, we need not take any notice of it here, its use being in many cases undecided, and the variation in the sound being in most cases too infinitesimal to be noticed by foreigners.

Of the Shifting Diphthong.—Although there is no real diphthong in the Italian language, there are some combinations of vowels which appear occasionally, whenever the principal stress in the pronunciation of that word is shifted from one to another syllable—*i.e.* the extra vowel appears with the appearance of the stress on that syllable, and disappears with the shifting of the stress to another syllable, as in the following verb, 'sonare,' *to play*:

io suono, *I play*	noi soniamo, *we play*
tu suoni, *thou playest*	voi sonate, *you play*
egli suona, *he plays*	eglino suonano, *they play*

So also the noun 'sonata,' from 'suono.'

allievo, *pupil*	allevare, *to educate*
bandiera, *flag*	banderuola, *little flag*
buono, *good*	bontà, *goodness*
cieco, *blind*	cecità, *blindness*
cielo, *sky*	celeste, *light blue*
coscienza, *conscience*	coscenzioso, *conscientious*
cuoio, *leather*	coriaceo, *leathery*
cuore, *heart*	coraggio, *courage*
duolo, *grief*	dolore, *sorrow*
fiero, *fierce*	feroce, *ferocious*
fuoco, *fire*	focolare, *fireplace*
giuoco, *play*	giocare, *to play*
lieto, *joyful*	letizia, *joy*
lieve, *light*	levità, *levity, lightness*
nuovo, *new*	novità, *novelty*
piede, *foot*	pedata, *kick*
pietra, *stone*	petraia, *stone-quarry*
ruota, *wheel*	rotaia, *railway track*
scienza, *science*	scenziato, *scientist*
scuola, *school*	scolare, *scholar*
Siena, *Sienna*	senese, *native of Sienna*
uomo, *man*	ometto, *little man*
uovo, *egg*	ovale, *oval*

Thus also with some verbs ending in *ere*:

io presiedo, *I preside*	noi presediamo, *we preside*
tu presiedi, *thou presidest*	voi presedete, *you preside*
egli presiede, *he presides*	eglino presiedono, *they preside*

This shifting, however, does not take place (*a*) when the *i* represents a letter in the root-word, and is not an amplification of the *e*, as in 'pieno (plenus),' *full*, 'pienezza,' *fullness*; (*b*) before *ng*: 'io vengo,' *I come*; 'to vieni'; 'egli viene,' &c.

Italian nouns being derived bodily from the ablative of the Latin, and there being no declension or other modification of the noun itself in Italian, its different cases are expressed by prefixing to it a preposition, with or without a definite or indefinite article. There being only two genders in the language, there are only two articles: 'il' for the masculine singular ('i' for the masculine plural), 'la' for the feminine singular ('le' for the feminine plural). As there are words which begin with an *s* followed by a consonant, to avoid that sibilant being placed between the *l* of the masculine definite article 'il' and another consonant, yet another form of that article has been invented—*i.e.* 'lo,' whose plural is 'gli.' All the above articles are rendered into English by *the*.

The indefinite Italian article is 'uno' for the masculine, and 'una' for the feminine, written also as 'un' and 'un',' rendered into English by *a, an, one*.

Although we mentioned above that all Italian words end with a vowel, if this final vowel is preceded by an *l, n*, or *r* it may be dropped, and we can write 'ben' for 'bene,' 'ciel' for 'cielo,' and 'far' instead of 'fare.' When the final vowel is preceded by *ll, rr*, or *nn*, whenever we like to drop the final vowel we must also eliminate one of the double consonants that precedes it, and write 'bel' for 'bello,' 'dan' for 'danno,' and 'por' for 'porre.' Moreover, such elimination is not to be replaced by an apostrophe. Feminines have not this advantage, the eliminated final having to be replaced by the apostrophe, as in other words.

There are cases in which the article may precede the preposition, as in 'quantunque noioso gli fosse il da lui dipartirsi,' 'all' ombra dell' agli inferi transito sposo,' 'and 'le più d' una sorte prodezze.'

There are cases in which the English indefinite article is omitted in Italian: 'egli è ambasciatore,' *he is an ambassador*; 'due e mezzo,' *two and a half*; 'mezza oncia,' *half an ounce*; 'cento,' *a hundred*; 'mille,' *a thousand*; 'così bella donna,' *such a beautiful lady*; 'che rumore,' *what a noise*; 'Pisa, città d' Italia,' *Pisa, a city of Italy*, &c.

In the following cases the English definite article is omitted in Italian: *George the Fifth*, 'Giorgio Quinto'; *London, the capital of England*, 'Londra, capitale dell' Inghilterra.'

The beautiful word *home* has no exact equivalent in Italian; the nearest approach to its meaning being expressed by the use of the word 'casa,' *house*, without the article.

Sometimes the English indefinite article is translated into Italian by the definite article, as: 'dieci soldi la libbra," *fivepence a pound*; 'lontano le mille miglia dal crederlo,' *very far (a thousand miles) from believing it*.

Whenever a noun is used in a general sense, the definite article must always precede it in Italian, as: 'le buone azioni meritano lode,' *good actions deserve praise*.

The article must also be used with names of

countries, as: 'la cara Inghilterra,' *dear England;* 'la bella Italia,' *beautiful Italy.*

All Italian titles must be preceded by the article, as: 'il generale Smith,' *General Smith;* 'il dottor Jones,' *Doctor Jones.* But titles which are not Italian take no article, as 'Lord Plymouth.'

Except when the possessive adjective precedes the name of a relation in the singular, without any other adjective, the definite article is always used with it, as: 'la mia penna,' *my pen;* 'il suo bastone,' *his stick.*

The definite article is also used with the names of the following towns: l'Aia, *the Hague;* il Cairo; l'Havre; la Mirandola; la Mecca; la Roccella; il Vasto.

The Italian prepositions are: 'di,' *of;* 'a,' *to, at;* 'da,' *from, at the house of;* 'in,' *in;* 'su,' *upon, on, above;* 'per,' *by, through, across, because;* 'con,' *with.* Very seldom they are used before a definite article without being joined to it, as follows:

al	allo	alla	ai	agli	alle	*to the*
col	collo	colla	coi	cogli	colle	*with the*
dal	dallo	dalla	dai	dagli	dalle	*from the*
del	dello	della	dei	degli	delle	*of the*
nel	nello	nella	nei	negli	nelle	*in the*
pel	pello	pella	pei	pegli	pelle	*for the*
sul	sullo	sulla	sui	sugli	sulle	*on the*

'Per' and 'con' are, however, often written apart from the article. *Some* or *any* are rendered in Italian by the preposition 'di' with the definite article in the singular, when meaning a part of the whole, as: 'noi abbiamo del pane,' *we have some bread;* 'eglino hanno del vino,' *they have some wine.* But the article is put in the plural when numbers are mentioned, as: 'voi avete dei libri,' *you have some books;* 'io ho delle fotografie,' *I have some photos.*

There being only two genders, the masculine and the feminine, in the Italian language, all nouns, whether of persons or things, are either masculine or feminine. Masculine are all nouns ending in *o*, with the single exception of 'la mano,' *the hand.* Nouns ending in *a* are generally feminine, although nouns derived from the Greek and some others are masculine, notwithstanding their ending with an *a*, as: 'il programma,' *the programme;* 'il clima,' *the climate.* There are very few nouns ending in *i* in the singular, and no rule governs them as to their gender. Thus we have: 'la tisi'; 'il dì,' *the day;* 'la crisi'; 'il Tamigi,' *the Thames;* 'il brindisi,' *the toast.*

Of the few nouns ending in *u*, generally written with the accent, 'Gesù,' 'Perù,' 'Esaù' are masculine; all the others are feminine.

The real difficulty is to distinguish the gender of nouns ending in *-e* in the singular, since there are as many which are feminine as masculine, and no general rule can be given to help the student except the advice of consulting the dictionary.

The formation of the plural presents no difficulty. All nouns form their plural by changing their final vowel into an *i*, with the exception of the nouns that end with an *-a* in the singular and are feminine. These form their plural with the letter *e*.

The exceptions to the above general rule are these:

(*a*) Nouns of one syllable are the same in the plural as in the singular, thus: 'il re,' *the king;* 'i re,' *the kings.*

(*b*) Nouns the final vowel of which bears an accent, thus: la verità, *the truth;* le verità, *the truths.*

(*c*) Nouns ending with a consonant: lo specimen, *the specimen;* gli specimen, *the specimens:* il caos, *the chaos;* i caos, *the chaos:* il lapis, *the pencil;* i lapis, *the pencils.*

(*d*) Nouns ending with *-i* in the singular: la crisi, *the crisis;* le crisi, *the crises:* l' azzeccagarbugli, *the pettifogger;* gli azzeccagarbugli, *the pettifoggers.*

(*e*) Nouns ending in *-ie* in the singular: la specie, *the species;* le specie, *the species.* 'Loro,' *their*, is the same in the masculine and feminine, singular and plural.

Nouns with two meanings in the singular have generally a different plural for each meaning.

l' anello, *the ring, the (hair) ringlet:* gli anelli, *rings;* le anella, *ringlets.*
il braccio, *the arm, the yard-stick:* le braccia, *arms;* i bracci, *yard-sticks.*
il cervello, *brains, mind;* i cervelli, *minds;* le cervella, *brains.*
il ciglio, *the eyelid, the brink;* i cigli, *the brinks;* le ciglia, *eyelids.*
il corno, *the horn;* i corni, *horns (instrument);* le corna, *horns (of animals).*
il dito, *inch, finger;* i diti, *inches;* le dita, *fingers.*
il filo, *thread (of cloth), (of plot);* i fili, *of cloth;* le fila, *of plot.*
il fondamento, *the foundation;* i fondamenti, *abstract;* le fondamenta, *masonry.*
il frutto, *fruit;* i frutti, *results;* le frutta, *eatables.*
il gesto, *gesture;* i gesti, *gestures;* le gesta, *great deeds.*
il legno, *carriage, wood, ship;* i legni, *ships, carriages;* le legna, *firewood.*
il membro, *member;* i membri, *members;* le membra, *limbs.*
il muro, *wall;* i muri, *walls (house);* le mura, *walls of town (of fortress).*
l' osso, *bone;* gli ossi, *bones;* le ossa, *remains of the dead.*
il riso, *rice, laughter;* i risi, *rice;* le risa, *laughter.*

Although not so frequently used as in some other languages, nouns may also be compounded in Italian, but without the hyphen. Such are:

A. altalena, *see-saw;* arcibello, *extra beautiful;* andirivieni, *maze;* antipapa, *anti-pope;* avanbraccio, *forearm;* antivigilia, *two evenings before;* arcobaleno, *rainbow;* accattapane, *beggar;* alidorato, *gold-winged;* arruffapopoli, *demagogue;* azzeccagarbugli, *pettifogger;* agrodolce, *sharp sauce;* acquavite, *brandy.*

B. bassorilievo, *bas-relief;* buonamano, *tip;* battistrada, *outrider;* baciamano, *king's reception at court;* batticuore, *heart-beating;* batti-

loro, *gold-beater*; bevilacqua, *teetotaller*; bellimbusto, *fop*; bissillabo, *a word of two syllables*; barbitonsore, *barber*; buttasello, *soldier's call to horse*; barbabietola, *beetroot*; benandata, *tip (on leaving)*; benessere, *welfare*; benvenuto, *welcome*; benestante, *well-off*; beccamorti, *gravedigger*.

C. capogiro, *dizziness*; capolavoro, *masterpiece*; capobanda, *bandmaster*; capocaccia, *head-huntsman*; capofila, *No. 1 of a soldier's line*; capomaestro, *master-builder*; cartapesta, *cardboard*; cartastraccia, *wrapping-paper*; cartapecora, *vellum*; cartasuga, *blotting-paper*; crepacuore, *heart-breaking*; cantafavola, *story-teller*; capitombolo, *somersault*; cavadenti, *dentist*; chiaroscuro, *shading*; conciatetti, *roof-mender*; cavalcavia, *viaduct*; cascamorto, *a fop*; cassapanca, *linen-chest*; caldallesse, *boiled chestnuts*.

D. dominedio, *God the Lord*; dormiveglia, *dozing*.

E. ex-uffiziale, *late officer* (ex- is generally used to denote a former office or position).

F. frastuono, *hubbub*; ferravecchi, *dealer in old iron*; francobollo, *postage stamp*; fruttivendolo, *fruiterer*; fuoruscito, *exiled*; fannullone, *loafer*.

G. gabbasanti, *hypocrite*; guastamestieri, *a man of all trades and master of none*; guardaboschi, *forester*; grancassa, *big drum*; girasole, *sunflower*; girovago, *tramp*; girarrosto, *turnspit*; granturco, *maize*.

I. ippocastani, *horse-chestnuts*; interlinea, *a line between two others*.

L. lavamani, *washstand*; luogotenente, *lieutenant*.

M. mirallegro, *congratulations*; manoscritto, *MS.*; melarancia, *orange*; malcaduco, *fits*; marciapiede, *pavement*; malaccorto, *unwary*; malvolere, *ill-will*; maggiordomo, *butler*; mappamondo, *the globes*; mangiapane, *loafer*; madreperla, *mother-of-pearl*; mezzogiorno, *noon, south*; mezzanotte, *midnight*.

N. noncuranza, *carelessness*; nubifendente, *cloud-cleaving*.

O. oltremare, *beyond the sea*; oltramontano, *beyond the Alps, popish*.

P. pescivendolo, *fishmonger*; portabandiera, *flag-bearer*; portalettere, *postman*; paracqua, *umbrella*; portavoce, *megaphone*; portafoglio, *portfolio*; paravento, *screen*; passatempo, *pastime*; portasigari, *cigar-case*; pomodoro, *tomato*; pettirosso, *robin-redbreast*; pomeriggio, *afternoon*; pianoforte, *piano*.

Q. qualcosa, *something*; quadrumano, *four-handed*; quadrupedo, *four-footed*.

R. retroguardia, *rearguard*; ragnatela, *spider-web*.

S. scaldaletto, *warming-pan*; similoro, *pinchbeck*; spaccalegna, *woodman*; salvadanaro, *money-box*; santacroce, *the A B C book*; sottocoppa, *saucer*; soppanno, *lining*; semicerchio, *half a circle*; semprevivo, *evergreen*; solleone, *dog-days*; spazzacammino, *chimney-sweeper*; stuzzicadenti, *tooth-pick*; saliscendi, *door-latch*; sordomuto, *deaf and dumb*.

T. terremoto, *earthquake*; terrapieno, *embankment*; tagliaborse, *cut-purse*.

V. voltafaccia, *turncoat*; valentuomo, *worthy man*; verderame, *verdigris*.

With the help of the preposition 'da' we can express the use or fitness of a noun, as: carta da scrivere, *writing-paper*; carta da sugo, *blotting-paper*; camera da pranzo, *dining-room*; nave da guerra, *man-of-war*; nave da pesca, *fishing-boat*, &c.

Some nouns only used in the plural are: gli alari, *the andirons*; i beni, *lands and houses, landed property*; i convenevoli, *social duties*; le cerimonie, *ceremonies*; gli avi, *the ancestors*; le froge, *the nostrils*; le fattezze, *the features*; le gramaglie, *mourning clothes*; l' intemperie, *the bad weather*; i lai, *the wailings, the lays*; i lari, *the household gods*; le mollette, *the tongs*; i mezzi, *the means*; le manotte, *the handcuffs*; le muriella, *the marbles*; le nenio, *the death-watch*; i nepoti, *the descendants*; gli omei, *the wailings*; le paure, *the bogeys*; i piati, *the pleadings*; i pressi, *the neighbourhood*; i paraggi, *the fore-shore*; i paternostri, *the beads of a rosary*; i quattrini, *money*; i ruderi, *the ruins*; le secche, *sandbanks*; le stoviglie, *crockery ware*; gli usatti, *military riding-boots*; le vettovaglie, *victuals*; i vezzi, *the charms*.

The following nouns are used only in the singular: il bottino, *the booty*; l' era, *the epoch*; il Medio Evo, *the Middle Ages*; il miele, *honey*; sire, *sire*; la politica, *politics*; l' afa, *heat-wave*; l' uopo, *the necessity*; il fio, *the penalty*; la morale, *the morals*, &c.

The following nouns have an irregular plural: la eco, gli echi; il Dio, gli Dei; il bue, i buoi; il miglio, le miglia; il migliaio, le migliaia; mille, mila; lo uovo, le uova; la moglie, le mogli.

The following nouns have no masculine: la mosca, *the fly*; l' ape, *the bee*; la rana, *the frog*; la volpe, *the fox*; la pulce, *the flea*; l' aquila, *the eagle*; la pecchia, *the tick*; la zanzara, *the mosquito*; la giraffa, *the giraffe*.

The following nouns have no feminine: il leopardo, *the leopard*; il corvo, *the crow*; il coniglio, *the rabbit*; il bracco, *the pointer*; il mastino, *the mastiff*; il topo, *the rat*; il sorcio, *the mouse*; il botolo, *the cur*.

Names which form their feminine irregularly are:

Dio, *God*; la Dea.
Doge, *Doge*; la dogaressa.
il cane, *the dog*; la cagna.
il compare, *godfather*; la comare.
il gallo, *the cock*; la gallina.
il leone, *the lion*; la leonessa.
il montone, *the ram*; la pecora.
il piccione, *the pigeon*; la colomba.

il porco, *the pig ;* la troia.
il toro, *the bull ;* la vacca.
l' eroe, *the hero ;* l' eroina.

Many other nouns are made feminine by the termination *-essa,* as: barone, baronessa; poeta, poetessa; filosofo, filosofessa, &c.

The following are used indifferently in the masculine and in the feminine gender, as: 'il tigre' and 'la tigre'; 'il lepre,' *the hare,* and 'la lepre'; 'il fronte' and 'la fronte,' *the forehead;* 'il fonte' and 'la fonte,' *the fountain;* 'il' and 'la folgore,' *the thunderbolt;* 'il' and 'la carcere,' *the prison;* 'il' and 'la gregge,' *the flock.*

However, some nouns change their meaning with the change in their gender, thus:

il capitale, *the capital (money)*	la capitale, *the capital (city)*
il consorte, *the husband*	la consorte, *the wife*
il fine, *the aim, the purpose*	la fine, *the end*
il prigione, *the prisoner*	la prigione, *the prison*

Nouns of trees are masculine and those of fruits feminine, as: il pero, *the pear-tree;* la pera, *the pear.*

Masculine nouns ending in *a* most frequently used: artista, *artist;* atmosfera, *atmosphere;* clima, *climate;* collega, *colleague;* aforisma, *aphorism;* asma, *asthma;* auriga, *chariot-driver;* antagonista, *antagonist;* dramma, *drama;* duca, *duke;* diadema, *diadem;* dogma, *dogma;* epigramma, *epigram;* emblema, *emblem;* enigma, *enigma;* stratagemma, *stratagem;* fantasma, *phantasm;* entusiasta, *enthusiast;* giornalista, *journalist;* idioma, *idiom;* idiota, *idiot;* monarca, *monarch;* poeta, *poet;* poema, *poem;* papa, *pope;* profeta, *prophet;* pianeta, *planet;* problema, *problem;* pirata, *pirate;* programma, *programme;* prisma, *prism;* proclama, *proclamation;* satirista, *satirist;* sistema, *system;* stemma, *escutcheon;* scisma, *schism;* sofisma, *sophism.*

Nouns with a different meaning according to their different gender: il fosso, *the pit;* la fossa, *the grave:* il gambo, *the stalk;* la gamba, *the leg:* il ghiaccio, *the ice;* la ghiaccia, *the ice-field:* il grido, *the shout;* la grida, *the proclamation:* il pezzo, *the piece;* la pezza, *the cloth-patch,* &c.

In order to keep in the plural the same hard sound that the letters *c* and *g* have in the singular, with words ending in *-ca* and *-ga* the letter *h* must be inserted in the plural between the *c* and the *e* and between the *c* and the *i,* and between the *g* and the *e* and between the *g* and the *i* of their plural, thus: 'la manica,' *the sleeve,* 'le maniche'; 'la paga,' *the pay,* 'le paghe'; 'il duca,' *the duke,* 'i duchi'; the only exception to this rule being with words ending in *-ologo,* as in 'teologo,' *theologian,* 'teologi.' The word 'Mago' has the plurals 'Magi,' *Magi* and maghi, *magicians.* 'Belga,' *Belgian,* plural 'Belgi.'

Nouns ending in *-co,* if of two syllables, take an *h* in the plural, according to the general rule, to strengthen the hard sound of the *c,* thus: 'il fico,' *the fig,* 'i fichi.' 'Greco,' *Greek,* and 'porco,' *pig,* are exceptions to this rule, their plural being 'Greci' and 'porci.' Words of more than two syllables ending in *-co* generally take no *h* in the plural, which is so far formed irregularly, as 'amico,' *friend,* 'amici.' This, however, is rather a hint than a rule, because there are many exceptions to it, and several such words are written indifferently with or without the *h* in their plural, as in the words 'equivoco,' *equivocal,* 'equivoci' and 'equivochi'; 'traffico,' *traffic,* 'traffici' and 'traffichi'; 'mendico,' *beggar,* 'mendici' and 'mendichi.'

Nouns ending in *-cia* and in *-gia,* without the stress on the *i,* which in them is used only to soften the sound of the letters *c* and *g,* drop the *i* in their plural (the *c* and the *g* being soft before the termination *-e* or *-i*), thus: 'faccia,' *face,* 'facce'; 'bragia,' *red hot coal,* 'brage.'

Nouns ending in *-io,* if there is no stress on the *i,* drop the final *o* to form their plural, as 'bacio,' *kiss;* plural 'baci.' If, however, there is the stress on the *i,* the final *o* becomes a second *i* in the plural, as 'mormorio,' *murmur,* 'mormorii.'

When, however, a noun without stress on the termination *i* could be mistaken for another similar word with a different meaning, the final *o* must be changed into a second *i,* as: 'principio,' *principle;* 'principii in the plural, so as not to mistake it for the word 'principi,' plural of 'principe,' *prince;* 'beneficio,' *benefit,* plural 'beneficii'; 'benefico,' *beneficent,* plural 'benefici': 'omicidio,' *murder,* plural 'omicidii'; 'omicida,' *murderer,* plural 'omicidi': 'tempio,' *temple,* 'tempii'; 'tempo,' *time,* 'tempi': 'giudicio,' *judgment,* 'giudicii'; 'giudice,' *judge,* 'giudici,' &c.

Nouns ending in *-ore* are masculine.

Nouns ending in *-iggine, -udine,* and *-uggine* are feminine.

The great majority of nouns ending in *-ione* are feminine; but to this there are several exceptions, as: il battaglione; il bastione; il settentrione, *the north;* il padiglione, *the pavilion;* il milione, *the million;* lo scorpione, *the scorpion;* lo storione, *the sturgeon;* il campione, *the champion;* and a few others.

The present participle of many verbs may be used as a noun, as: l' amante, *the lover;* il cantante, *the singer.*

Other parts of speech which may be used also as nouns are:

The infinitive: 'Il perder tempo a chi più sa, più spiace,' *to waste time grieves most those who know most.*

The past participle: 'Dal detto al fatto c' è un gran tratto,' *there is many a slip between the cup and the lip.*

The adverb: 'Il perchè non si sa,' *the reason why is not known.*

The present participle: 'L' amante del vero,' *the lover of truth.*

The adjective: 'Tanto m' è bel, quanto a te piace,' *your pleasure is my will.*

The interjection: 'Gli omei si sentivano da lontano,' *the wailings were heard from afar.*

The gerund: 'La monacanda piangeva alla dirotta,' *the girl, who was becoming a nun, cried unceasingly.*

Nouns of Kinship.—Arcibisavolo, *great-great-grandfather;* avo or avolo, *grandfather;* bisavolo, *great-grandfather;* celibe, *bachelor;* cugino germano, *first cousin;* cadetto, *younger brother;* cugino, *cousin;* cognato, *brother-in-law;* consorte, (m.) *husband,* (f.) *wife;* compare, *godfather;* comare, *godmother;* figlio, *son;* figlia, *daughter;* figliastro, *step-son;* fratello (carnalo), *brother;* gemello, *twin-brother;* fratello uterino, *brother on the mother's side;* fratello di latte, *foster-brother;* genero, *son-in-law;* genitore, *father;* genitrice, *mother;* madre, *mother;* matrigna, *stepmother;* marito, *husband;* moglie, *wife;* nuora, *daughter-in-law;* nubile, *unmarried* (*woman*); nonno, *grandfather;* nipote, *grandson, granddaughter, nephew, niece;* prozio, *great-uncle;* pronipote, *descendant;* primogenito, *first-born;* padre, *father;* parente, *relation;* padrigno, *stepfather;* suocero, *father-in-law;* sorella, *sister;* zio, *uncle.*

Modifications of Italian Words.

On the modification of Italian words depend a great deal of the charm and beauty of the Italian language. By modifying the spelling of a word we add to its original meaning one, two, or even three adjectives. No article, preposition, conjunction, interjection, or pronoun may be modified; but all those parts of speech hardly fill up the twentieth part of an Italian dictionary. The parts of speech which may undergo one or more modifications are the noun, the adjective, the verb, and the adverb—*i.e.* the immense majority of Italian words.

The different modifications in the spelling, and consequently in the meaning, of words are numberless, and they are not all capable of modifying every word. No rules, except those of euphony, govern the employment of these modifications; and a foreigner should never attempt to use them, unless he has seen them before in black and white, since he is most likely to add a wrong modification to the word. He will be quite safe and correct in making use of the needful adjectives, and leave alone any doubtful modification. But if he wishes to make real progress in the study of the language, he should carefully copy in a note-book all the modified words which he meets with in his reading or hears in his conversation. This is indispensable, since dictionaries (except very voluminous ones) rarely register such modified words.

The student should not feel discouraged by this, but redouble his endeavours, which will be rewarded in this case by the most useful and satisfactory knowledge, that will open to him the classical works of the best writers of all periods of Italian literature.

With regard to the modification of Italian words, we must observe that the termination *-one* is always masculine, even when added to a feminine noun.

As for the additional meaning of modifications, this is sufficiently explained by their translation in the following examples:

bello, *beautiful*	bellino, *pretty*
campana, *bell*	campanello, *hand-bell*
giallo, *yellow*	giallognolo, *yellowish*
il cappello, *the hat*	il cappellino, *the small hat*
il giovine, *the young man*	il giovinotto, *a strong young man*
il letto, *the bed*	il lettuccio, *the cot*
il libro, *the book*	il libretto, *the little book, the book of words of the opera*
il libro, *the book*	il librone, *the big book*
il pittore, *the painter*	il pittoraccio, *the dauber*
il ramo, *the bough*	il ramicello, *the twig*
la casa, *the house*	la casetta, *the small house*
la porta, *the door*	il portone, *the big door, the front-door*
medico, *doctor*	mediconzolo, *quack*
poeta, *poet*	poetucolo, *poetaster*

and numberless other modifications.

Often a modification gives quite a new meaning to the word, as:

albero, *tree*	alberello, *phial*
bello, *beautiful*	belletto, *rouge*
carta, *paper*	cartuccia, *cartridge*
casa, *house*	casella, *pigeon-hole*
cavallo, *horse*	cavalletto, *easel*
cavallo, *horse*	cavallone, *sea-wave, sea-horse*
gallina, *hen*	gallinaccio, *turkey*
occhio, *eye*	occhiello, *buttonhole*
padre, *father*	padrino, *second (in a duel)*

A word already modified may take a second modification, as:

birbone, *rascal*	birbonaccio, *a very bad rascal*
campanello, *little bell*	campanellino, *a nice little bell*
casetta, *little house*	casettina, *a nice little house*
cassetta, *little box*	cassettina, *nice little box*
storiella, *short story*	storiellina, *nice little story*
tavolino, *little table*	tavolinuccio, *a very little table*

The changes in the terminations of verbs being used for their conjugation, their modification takes place after the root of the verb and before its termination—that is to say, before the last three letters of its infinitive, thus:

cantare, *to sing.*
cantarellare, *to hum in tune.*
canticchiare, *to hum out of tune.*
saltare, *to jump.*
saltarellare, *to skip.*
scrivere, *to write.*
scribacchiare, *to scrawl.*

Gender of Adjectives:

Adjectives ending in *-a* are all feminine.

Adjectives ending in *-o* are all masculine.

Adjectives ending in *-e* or in *-i*, in the singular, are both masculine and feminine. There are no adjectives ending in *-u*.

Plural of Adjectives.—All adjectives have their plural ending in *-i*, with the exception of

those ending in *-a*, which have their plural in *-e*, thus:

SINGULAR.	PLURAL.
bella, *beautiful*	belle (feminine)
cara, *dear*	care (feminine)
caro, *dear*	cari (masculine)
felice, *happy*	felici (feminine and masculine)
pari, *equal*	pari (feminine and masculine)

Formation of the Comparatives of Adjectives:

Più, *more;* meno, *less.*

Più ricco di suo fratello, *richer than his brother.*
Più ricco che non suo fratello, *richer than his brother.*
Meno dotto del padre, *less learned than his father.*
Meno dotto che non il padre, *less learned than his father.*

Così . . . come, *as . . . as.*
Così . . . che, *as . . . as.*
Tanto . . . quanto, *as . . . as.*

Così buono che gentile, *as good as kind.*
Così studioso come ubbidiente, *as studious as obedient.*
Tanto largo quanto lungo, *as long as broad.*

The superlative absoluto is formed by adding to the positive adjective the termination *-issimo.*

alto, *high*	altissimo, *very high*
amabile, *amiable*	amabilissima, *very amiable*
cara, *dear*	carissima, *very dear*
lungo, *long*	lunghissimo, *very long*

Formation of the superlative relative of adjectives:

With 'il più,' *the most,* and 'il meno,' *the least.*

Questa è la più bella camera nel collegio, *this is the most beautiful room in the college.*
Quello è il meno studioso degli studenti, *that one is the least studious of the students.*

The following comparisons are formed irregularly:

alto, *high;* superiore, *higher;* il superiore, *highest;* supremo, *very high.*
basso, *low;* inferiore, *lesser;* l' inferiore, *the least;* infimo, *very low.*
buono, *good;* migliore, *better;* il migliore, *the best;* ottimo, *very good.*
cattivo, *bad;* peggiore, *worse;* il peggiore, *the worst;* pessimo, *very bad.*
grande, *great;* maggiore, *greater;* il maggiore, *the greatest;* massimo, *very great.*
piccolo, *little;* minore, *smaller;* il minore, *smallest;* minimo, *very small.*

About the position of the adjective, whether it should come before or after the noun it qualifies, no hard-and-fast rule can be given. Usually an adjective precedes the noun if it is a shorter word, and follows it when longer.

If, however, the adjective denotes a physical quality, it must follow the noun, as 'guanti bianchi,' *white gloves;* 'cappello nero,' *black hat.* There are some adjectives which change their meaning with the change of their position, as:

cassa grande, *large box, chest*	gran cassa, *big drum*
contadino semplice, *only a peasant*	semplice contadino, *gullible peasant*
doppio amico, *mutual friend*	amico doppio, *false friend*
il figlio solo, *only the son*	il solo figlio, *the only son*
la mano stanca, *the left hand*	la stanca mano, *the tired hand*
novelle certe, *true news*	certe novelle, *some news*
questo detto, *this saying*	detto questo, (*having*) *said this*
tempi cattivi, *hard times*	cattivo tempo, *bad weather*
un uomo certo, *a real man*	un certo uomo, *somebody*
un uomo solo, *a bachelor*	solo un uomo, *only one man*
uomo dabbene, *a worthy man*	dabben uomo, *a fool*
uomo galante, *effeminate man*	galantuomo, *a gentleman*
uomo grande, *tall man*	grande uomo, *great man*

Adjectives agree with the noun in gender and number:

i cari compagni di scuola, *the dear schoolfellows.*
il caro amico, *the dear friend.*
la cara sorella, *the dear sister.*
le care memorie, *the dear memories.*

Possessive Adjectives.

SINGULAR.		PLURAL.		
MASCULINE.	FEMININE.	MASCULINE.	FEMININE.	
il mio	la mia	i miei	le mie	*my, mine*
il tuo	la tua	i tuoi	le tue	*thy, thine*
il suo	la sua	i suoi	le sue	*his, hers*
il nostro	la nostra	i nostri	le nostre	*our, ours*
il vostro	la vostra	i vostri	le vostre	*your, yours*
il loro	la loro	i loro	le loro	*their, theirs*

When they precede in the singular a noun denoting relationship, and there is no other adjective, they are used without the article: 'mio fratello,' *my brother;* 'il mio caro fratello'; 'il fratello mio.' 'Loro' is always written with the article.

The cardinal numerals are:

uno	1	trentuno	31
due	2	trentadue	32
tre	3	trentatrè	33
quattro	4	quaranta	40
cinque	5	quarantuno	41
sei	6	quarantadue	42
sette	7	quarantatrè	43
otto	8	cinquanta	50
nove	9	cinquantuno	51
dieci	10	cinquantadue	52
undici	11	cinquantatrè	53
dodici	12	sessanta	60
tredici	13	sessantuno	61
quattordici	14	sessantadue	62
quindici	15	sessantatrè	63
sedici	16	settanta	70
diciassette	17	settantuno	71
diciotto	18	settantadue	72
diciannove	19	settantatrè	73
venti	20	ottanta	80
ventuno	21	novanta	90
ventidue	22	cento	100
ventitrè	23	duecento	200
ventiquattro	24	trecento	300
venticinque	25	novecentosette	907
ventisei	26	mille	1000
ventisette	27	due mila	2000
ventotto	28	un milione	1,000,000
ventinove	29	due milioni	2,000,000
trenta	30	un miliardo	1,000,000,000

N.B.—'Uno' has the feminine 'una.' 'Mille' has the irregular plural 'mila.' 'Milione' and 'miliardo' are treated as nouns, with the plural 'milioni' and 'miliardi.'

'Tre,' when ending a numeral, takes the accent—'ottantatrè,' 83; but takes no accent when preceding another numeral, as 'trecento, tremila,' &c.

'Cento' has no plural: 'duecento,' 200; 'novecento,' 900.

The ordinal numerals are treated as adjectives, with a masculine and feminine gender, and with a singular and plural number:

primo, prima, primi, prime	1st
secondo	2nd
terzo	3rd
quarto	4th
quinto	5th
sesto	6th
settimo	7th
ottavo	8th

nono	9th
decimo	10th
undecimo	11th
duodecimo *or* dodicesimo	12th
tredicesimo *or* decimoterzo	13th
quattordicesimo *or* decimoquarto	14th
quindicesimo, decimoquinto	15th
sedicesimo, decimosesto	16th
diciassettesimo, decimosettimo	17th
diciottesimo, decimottavo	18th
diciannovesimo, decimonono	19th
ventesimo	20th
ventunesimo, ventesimoprimo	21st
ventiduesimo, ventesimosecondo	22nd
trentesimo	30th
trentesimoprimo	31st
quarantesimo	40th
cinquantesimo	50th
sessantesimo	60th
settantesimo	70th
ottantesimo	80th
novantesimo	90th
centesimo	100th
centesimoprimo	101st
duecentesimo	200th
novecentesimo	900th
millesimo	1000th
milionesimo	1,000,000th
miliardesimo	1,000,000,000th
penultimo	*last but one*
ultimo	*the last*

Except for the first of the month, the cardinal numerals are used in dates: 'Il primo aprile,' *the first of April;* 'il due agosto,' *the second of August.*

As in English, the ordinal numbers are used with the names of kings: 'Eduardo Settimo, Giorgio Quinto.' Note the elimination of the definite article.

una volta, *once*	doppio, *twofold*
due volte, *twice*	triplo, *threefold*
tre volte, *three times, &c.*	quadruplo, *fourfold, &c.*

The days of the week are:

Lunedì (*the day of the Moon,* Luna), *Monday.*
Martedì (*the day of Mars*), *Tuesday.*
Mercoledì (*the day of Mercury*), *Wednesday.*
Giovedì (*the day of Jove*), *Thursday.*
Venerdì (*the day of Venere,* Venus), *Friday.*
Sabato (*the Sabbath*), *Saturday.*
Domenica (*the day of* Dominus, *the Lord*), *Sunday.*

'Dì,' from the Latin 'dies,' means *day.*

The names of the months are:

Gennaio (*from* Janus), *January.*	June (Junius), *June.*
Febbraio, (februarius) *February.*	Luglio (Julius), *July.*
Marzo (Mars), *March.*	Agosto (Augustus), *August.*
Aprile (aper, *Spring*), *April.*	Settembre (septem), *September.*
Maggio (Majus), *May.*	Ottobre (octo), *October.*
	Novembre (novem), *November.*
	Decembre (decem), *December.*

The Roman year, beginning in March, explains the numeral names given to the last four months.

The names of the four seasons are:

Primavera, *Spring.*	Autunno, *Autumn*
Està, *Summer.*	Inverno, *Winter.*

The hours of the day are expressed by prefixing the feminine definite article to the cardinal numeral, thus:

sono le (ore) tre, *it is three o'clock.*
sono le tre e un quarto, *it is a quarter past three.*
sono le tre meno un quarto, *it is a quarter to three o'clock.*
sono le tre e mezzo, *it is half-past three o'clock.*
sono le tre e tre quarti, *it is a quarter to four o'clock.*
sono le quattro meno un quarto, *it is a quarter to four o'clock.*

A second numeral, after the one denoting the hours, states the minutes:

sono le sei e nove, *it is nine minutes past six.*
sono le sette meno otto, *it is eight minutes to seven.*

With the number *one*, the verb is naturally put in the singular:

È l' una ('ora' understood), *it is one o'clock.*

For the railway time the hours are counted up to twenty-four, from one midnight to another.

Noon is 'mezzogiorno'; and *midnight* is 'mezzanotte.'

The Auxiliary Verbs

'Essere' and 'stare' mean *to be.* 'Essere' is used when the state is permanent, 'stare' when the state is transitory. Thus: 'Io sto scrivendo,' *I am writing* (*I do not write always*); 'egli sta nell' altra camera,' *he is in the other room* (*now*); 'noi siamo alti,' *we are tall;* 'elleno sono Inglesi,' *they are English.*

In their compound tenses 'essere' and 'stare' are used together; 'stato,' the past participle of 'stare,' being added to the verbal forms of 'essere': 'Io sono stato,' *I have been;* 'ella era stata,' *she had been.* Note that the compound tenses of 'essere' are formed in Italian with *to be,* and not *to have,* as in English.

The conjugation of

avere, *to have*	essere, *to be*	stare, *to be*
Indicative Mood. Present Tense.		
io ho, *I have*	io sono, *I am*	io sto, *I am*
tu hai, *thou hast*	tu sei, *thou art*	tu stai, *thou art*
egli ha, *he has*	egli è, *he is*	ella sta, *she is*
noi abbiamo, *we have*	noi siamo, *we are*	noi stiamo, *we are*
voi avete, *you have*	voi siete, *you are*	voi state, *you are*
eglino hanno, *they have*	elleno sono, *they* (f.) *are*	elleno stanno, *they* (f.) *are*
Imperfect Tense.		
aveva, *I had*	era, *I was*	stava, *I was*
avevi, *thou hadst*	eri, *thou wert*	stavi, *thou wert*
aveva, *he had*	era, *he was*	stava, *he was*
avevamo, *we had*	eravamo, *we were*	stavamo, *we were*
avevate, *you had*	eravate, *you were*	stavate, *you were*
avevano, *they had*	erano, *they were*	stavano, *they were*
Past Definite.		
ebbi, *I had*	fui, *I was*	stetti, *I was*
avesti, *thou hadst*	fosti, *thou wert*	stesti, *thou wert*
ebbe, *he had*	fu, *he was*	stette, *he was*
avemmo, *we had*	fummo, *we were*	stemmo, *we were*
aveste, *you had*	foste, *you were*	steste, *you were*
ebbero, *they had*	furono, *they were*	stettero, *they were*

Note.—The personal pronoun is generally omitted before the verb.

Future Tense.		
avrò, *I shall have*	sarò, *I shall be*	starò, *I shall be*
avrai, *thou shalt have*	sarai, *thou shalt be*	starai, *thou shalt be*
avrà, *he shall have*	sarà, *he shall be*	starà, *he shall be*
avremo, *we shall have*	saremo, *we shall be*	staremo, *we shall be*
avrete, *you shall have*	sarete, *you shall be*	starete, *you shall be*
avranno, *they shall have*	saranno, *they shall be*	staranno, *they shall be*

CONDITIONAL MOOD.

avrei, *I would have*	sarei, *I would be*	starei, *I would be*
avresti, *thou wouldst have*	saresti, *thou wouldst be*	staresti, *thou wouldst be*
avrebbe, *he would have*	sarebbe, *he would be*	starebbe, *he would be*
avremmo, *we would have*	saremmo, *we would be*	staremmo, *we would be*
avreste, *you would have*	sareste, *you would be*	stareste, *you would be*
avrebbero, *they would have*	sarebbero, *they would be*	starebbero, *they would be*

IMPERATIVE MOOD.

abbi, *have (thou)*	sii, *be (thou)*	stii, *be (thou)*
abbia, *(let him) have*	sia, *(let him) be*	stia, *(let him) be*
abbiamo, *(let us) have*	siamo, *(let us) be*	stiamo, *(let us) be*
abbiate, *have (you)*	siate, *be (you)*	stiate, *be (you)*
abbiano, *(let them) have*	siano, *(let them) be*	stiano, *(let them) be*

SUBJUNCTIVE MOOD. PRESENT TENSE.

ch' io abbia, *that I may have*
che tu abbia, *that thou mayest have*
ch' egli abbia, *that he may have*
che noi abbiamo, *that we may have*
che voi abbiate, *that you may have*
ch' eglino abbiano, *that they may have*

ch' io sia, *that I may be*
che tu sia, *that thou mayest be*
ch' egli sia, *that he may be*
che noi siamo, *that we may be*
che voi siate, *that you may be*
ch' eglino siano, *that they may be*

che io stia, *that I may be*
che tu stia, *that thou mayest be*
ch' egli stia, *that he may be*
che noi stiamo, *that we may be*
che voi stiate, *that you may be*
ch' eglino stiano, *that they may be*

IMPERFECT TENSE.

s' io avessi, *if I had*	se io fossi,	se io stessi, *if I were*
se tu avessi, *if thou hadst*	se tu fossi,	se tu stessi, *if you were*
s' egli avesse, *if he had*	s' egli fosse,	s' egli stesse, *if he were*
se noi avessimo, *if we had*	se noi fossimo,	se noi stessimo, *if we were*
se voi aveste, *if you had*	se voi foste,	se voi steste, *if you were*
s' eglino avessero, *if they had*	s' eglino fossero,	s' eglino stessero, *if they were*

THE GERUND (used as Present Participle).

avendo, *having*	essendo, *being*	stando, *being*

PAST PARTICIPLE.

avuto, *had*	stato, *been*	stato, *been*

The Regular Verbs

The regular conjugations of the Italian verbs are three, and they are distinguished from each other by the vowel which precedes the final syllable *-re* of their infinitive.

The first vowel, *a*, denotes the verbs of the First Conjugation.

The second vowel, *e*, denotes the verbs of the Second Conjugation.

The third vowel, *i*, denotes the verbs of the Third Conjugation. Thus:

volare, *to fly*. vendere, *to sell*. servire, *to serve*.

In conjugating an Italian verb, the first thing to do is to divide its infinitive into the root and the termination. This is done by separating the last three letters of the infinitive from the preceding ones: 'vol-are,' 'vend-ere,' 'serv-ire.' The last three letters are the termination, the preceding ones are the root of the verb.

Throughout the conjugation the 'root' never changes, and is always present. The 'termination' changes throughout the whole conjugation.

CONJUGATIONS OF THE REGULAR VERBS.

INFINITIVE.

I.	II.	III.
volare, *to fly*	vendere, *to sell*	servire, *to serve*
(vol-are)	(vend-ere)	(serv-ire)

Whenever the termination is omitted here, it is like the one on its immediate left.

INDICATIVE MOOD. PRESENT TENSE.

I fly, &c.	*I sell, &c.*	*I serve, &c.*
I am flying, &c.	*I am selling, &c.*	*I am serving, &c.*
I do fly, &c.	*I do sell, &c.*	*I do serve, &c.*
vol-o	vend —	serv —
-i		
-a		
-iamo		
-ate	-ete	-ite
-ano	-ono	

IMPERFECT TENSE.

I was flying, &c.	*I was selling, &c.*	*I was serving, &c.*
vol-va	vend-eva	serv-iva
-avi	-evi	-ivi
-ava	-eva	-iva
-avamo	-evamo	-ivamo
-avate	-evate	-ivate
-avano	-evano	-ivano

PAST DEFINITE.

I did fly, &c.	*I did sell, &c.*	*I did serve, &c.*
vol-ai	vend-ei	serv-ii
-asti	-esti	-isti
-ò	-è	-ì
-ammo	-emmo	-immo
-aste	-este	-iste
-arono	-erono	-irono

FUTURE TENSE.

I shall fly, &c.	*I will sell, &c.*	*I shall serve, &c.*
I will fly, &c.	*I shall sell, &c.*	*I will serve, &c.*
vol-erò	vend —	serv-irò
-erai	—	-irai
-erà	—	-irà
-eremo	—	-iremo
-erete	—	-irete
-eranno	—	-iranno

IMPERATIVE MOOD.

do fly (thou), &c.	*do sell (thou), &c.*	*do serve (thou), &c*
vol-a	vend-i	serv —
-i	-a	—
-iamo		
-ate	-ete	-ite
-ino	-ano	

CONDITIONAL MOOD. PRESENT TENSE.

I would fly, &c.	*I would sell, &c.*	*I would serve, &c.*
I should fly, &c.	*I should sell, &c.*	*I should serve, &c.*
vol-erei	vend —	serv-irei
-eresti		-iresti
-erebbe		-irebbe
-eremmo		-iremmo
-ereste		-ireste
-erebbero		-irebbero

SUBJUNCTIVE MOOD. PRESENT TENSE.

That I may fly, &c.	*That I may sell, &c.*	*That I may serve, &c.*
che io vol-i	ch' io vend-a	ch' io serv —
che tu -i	che tu -a	che tu —
ch' egli -i	ch' egli -a	ch' egli —
che noi -iamo	che noi -iamo	che noi —
che voi -iate	che voi -iate	che voi —
ch' eglino -ino	ch' eglino -ano	ch' eglino —

IMPERFECT TENSE.

If I fled, &c. Were I to fly, &c.	*If I sold, &c. Were I to sell, &c.*	*If I served, &c. Were I to serve; &c.*
se vol-assi	se vend-essi	se serv-issi
-assi	-essi	
-assimo		-issimo
-aste	-este	-iste
	-essero	-issero

PRESENT PARTICIPLE (seldom used).

flying	*selling*	*serving*
vol-ante	vend-ente	serv-ente

PAST PARTICIPLE.

fled	*sold*	*served*
vol-ato	vend-uto	serv-ito

GERUND (generally used instead of Present Participle).

flying	*selling*	*serving*
vol-ando	vend-endo	serv-endo

Irregular verbs are very numerous in Italian—there are over seven hundred of them; but, with the exception of about a score, they have irregular terminations *only* in the 1st and 3rd person singular and in the 3rd person plural of the past definite, and in the past participle. That is to say, they are conjugated regularly throughout, and have only four irregular forms recurring in the same places.

Verbs altogether irregular are the following:

andare, *to go.*	salire, *to ascend.*
dare, *to give.*	sapere, *to know.*
dire, *to say.*	sedere, *to sit down.*
dolere, *to ache.*	spegnere, *to extinguish.*
dovere, *to be obliged.*	tenere, *to hold.*
fare, *to do, to make.*	trarre, *to draw.*
morire, *to die.*	valere, *to be worth.*
parere, *to seem.*	vedere, *to see.*
porre, *to put.*	venire, *to come.*
potere, *to be able.*	volere, *to be willing.*
rimanere, *to remain.*	

'Udire,' *to hear*, is only in so far irregular that it changes the initial *u* into *o* whenever the stress falls on it, as 'io odo, tu odi, egli ode, noi udiamo, voi udite, eglino odono,' &c. 'Uscire' changes the *u* into *e* whenever the stress falls on the initial *u*, as 'esco, esci, esce, usciamo, uscite, escono,' &c. The *o* of 'dovere' becomes *e* in the similar instance: 'devo, devi,' &c.

In the regular verbs the accent on the 3rd person singular of the past definite is explained by the suppression of the last vowel in the old and obsolete termination, as 'amò' for 'amoe,' or by the suppression of the last syllable, as 'vendè' for 'vendette.'

In the 1st and 3rd person singular of the future the accent is explained thus: 'vendere ho,' *I have to sell*, becomes 'vendere ò'; and 'venderò,' 'vendere ha,' *he has to sell*, becomes 'vendere à,' 'venderà'—the silent *h* in 'ho, hai, ha' being replaced in modern Italian by the accent.

The 'verbi servili' (used as auxiliaries) are:

dovere, potere, sapere, volere,

and their dependent verb takes in its compound tenses the auxiliary required by this verb, as illustrated by the following examples: 'Egli era dovuto andarci,' *he was obliged to go there*; 'egli avrebbe dovuto vederlo,' *he ought to have seen him.* 'Egli non sarebbe potuto partire quel giorno,' *he would not have been able to start that day*; 'egli non avrebbe potuto scrivergli,' *he would not have been able to write to him.* 'Egli non è saputo andarvi,' *he was unable to go there*; 'egli non ha saputo farlo,' *he was unable to do it.* 'Egli non è voluto andarci,' *he would not go there*; 'egli non ha voluto comprarlo,' *he would not buy it.*

Adverbs in Italian are formed by adding the termination *-mente* to the feminine form of the adjective, thus: 'piana,' *slow*; 'pianamente,' *slowly*: 'felice,' *happy*; 'felicemente,' *happily*: 'celere,' *quick*; 'celeremente,' *quickly*.

When the adjective ends with *-e*, and is preceded by an *l* or by an *r*, the final *e* is eliminated, thus: 'amabile,' *amiable*; 'amabilmente,' *amiably*: 'anteriore,' *previous*; 'anteriormente,' *previously*.

The comparative and superlative of adverbs are formed as with adjectives: 'più facilmente,' *more easily*; 'il più facilmente,' *the most easily*; 'facilissimamente,' *very easily*.

The following are irregularly formed:

bene, *well*;	meglio, *better*;	il meglio, *best*;	benissimo, *very well.*
male, *badly*;	peggio, *worse*;	il peggio, *worst*;	malissimo, *very badly.*
molto, *much*;	più, *more*;	il più, *most*;	moltissimo, *very much.*
poco, *little*;	meno, *less*;	il meno, *least*;	pochissimo, *very little.*

Adjectives may be also used adverbially without any modification, as: 'piano,' *slowly*; 'forte,' *loudly*, &c.

The Italian language is particularly abundant in idiomatic adverbial phrases, like the following:

a babbo morto, *post-obiit.*	rompicollo, *at a break-neck rate.*
a bizzeffe, *plentifully.*	a spron battuti, *at full gallop.*
a bocca baciata, *easily.*	a stento, *with difficulty.*
a braccetto, *arm-in-arm.*	a un dipresso, *nearly.*
a bruciapelo, *point-blank.*	a un pelo di, *very near.*
a capello, *exactly.*	al dì d' oggi, *nowadays.*
a cavalluccio, *pick-a-back.*	all' ingrosso, *wholesale.*
a diritto o a traverso, *by hook or by crook.*	alla barba di, *in spite of.*
a faccia tosta, *barefacedly.*	alla buon' ora, *at last.*
a fior di, *flush with.*	alla chetichella, *quietly, on the sly.*
a forza di, *by dint of.*	alla difilata, *straightway.*
a galla, *floating.*	alla fin fine, *after all.*
a giorni, *shortly.*	alla meglio, *as best one can.*
a grandi giornate, *with forced marches.*	alla peggio, *at the worst.*
a malincuore, *unwillingly.*	alle spalle di, *at the expense of.*
a marcio dispetto, *in spite of.*	bel bello, *slowly.*
a menadito, *on the fingers' tips.*	buccia buccia, *skin-deep.*
al minuto, *retail.*	da parte, *aside.*
a occhi chiusi, *blindly.*	da sè a sè, *alone.*
a occhio e croce, *freely, without payment.*	da senno, *in earnest.*
a occhio nudo, *with naked eye.*	da sezzo, *lastly.*
a picco, *sheer.*	di buon grado, *willingly.*
a piedi, *on foot.*	di buon mattino, *early in the day.*
a piene mani, *abundantly.*	di peso, *bodily.*
a più non posso, *with all one's might.*	di tanto in tanto, *now and then.*
a più potere, *with all one's might.*	fuor fuora, *through.*
a portata di, *within reach.*	giù di lì, *thereabout.*
a quattr' occhi, *tête-à-tête.*	in capelli, *bareheaded.*
	in corso di posta, *by return.*
	in media, *on the average.*

in un amen, *quickly.*	li per li, *at once.*
in un attimo, *in a twinkling.*	man mano, *gradually.*
io come io, *as for me.*	ogni tanto, *now and then.*
lemme lemme, *slowly.*	punto e basta, *enough.*

The personal pronouns already mentioned in the conjugations of the verbs are:

io, *I*	noi, *we*
tu, *thou*	voi, *you*
egli, *he*	eglino, *they* (m.)
ella, *she*	elleno, *they* (f.)

'Egli' is often written 'ei' or 'e'.' But there are others:

questo, *this man*	questa, *this woman*
questi, *these men*	queste, *these women*
cotesto, *that man*	cotesta, *that woman*
cotesti, *those men*	coteste, *those women*
quello, *that man* (yonder)	quella, *that woman* (yonder)
quelli, *those men* (yonder)	quelle, *those women* (yonder)

Also the irregular forms for the masculine singular nominative:

questi, *this man*	quegli, *that man* (yonder)
costui, *this man*	costei, *this woman*
costoro, *these men*	costoro, *these women*
cotestui, *that man*	cotestei, *that woman*
cotestoro, *those men*	cotestoro, *those women*
colui, *that man* (yonder)	colei, *that woman* (yonder)
coloro, *those men* (yonder)	coloro, *those women* (yonder)

The irregular forms 'questi' and 'quegli,' only for the nominative singular.

'Chi,' *who,* is masculine and feminine singular; and plural only with the verb 'essere.'

Other personal pronouns are:

alcuno, qualcuno, qualcheduno, *someone* (m.).
alcuna, qualcuna, qualcheduna, *someone* (f.)

alcuno, *some man*	alcuna, *some woman*
alcuni, *some men*	alcune, *some women*
taluno, *some man*	taluna, *some woman*
taluni, *some men*	talune, *some women*
ognuno, *each man*	ognuna, *each woman* (no plur.)
chiunque, *whoever* (m. and f., no plural)	
qualcuno, *some man*	qualcuna, *some woman* (no plur.)

Conjunctive personal pronouns are:

mi, *to me, me*	ci, *to us, us*
ti, *to thee, thee*	vi, *to you, you*
gli, *to him*	li, *them* (m.)
le, *to her*	le, *them* (f.)
lo, il, *him*	loro, *to them, them* (m. and f.)
si, *himself, herself*	si, *themselves* (m. and f.)
la, *her*	si, *to themselves* (m. and f.)

In conversation, or in letters, when using the 3rd person, 'Le' means *to Your Lordship, to Your Ladyship;* 'Lei' and 'La' mean *Your Lordship, Your Ladyship.*

Absolute personal pronouns are also

me, *me;* te, *thee;* lui, *him;* lei, *her;* desso, *he;* dessa, *she.*

'Che,' *who, what, which,* is the most used of all pronouns; it is masculine and feminine, singular and plural, and is used for persons and things. 'Ne,' *of him, of her, of it, of them.*

The conjunctive pronoun precedes the verb in the indicative, the conditional, the subjunctive, and the imperative negative, and is not joined to it, as 'mi vide,' *he saw me.* It follows the verb when in the imperative affirmative, the past participle, the infinitive, and the gerund, when it is always joined to the verb, as 'Datami la lettera, egli partì,' *having given me the letter, he went away.*

'Loro' is never joined to the verb.

For the sake of euphony, when two conjunctive pronouns are together, the *i* of the first is modified into an *e.* Thus, instead of writing 'mi lo disse,' *he told it to me,* you must write 'me lo disse,' and take care to remember that that 'me' has nothing to do with the accusative 'me,' but stands there for the dative 'mi,' *to me.*

The difference between 'quale' and 'il quale' is best shown thus: 'Quale libro volete?' *which book do you want?* 'Il libro, il quale volete,' *the book, which you want.* 'Quale il padre, tale il figlio,' *as the father, so the son.* 'Quali i fioretti dal notturno gelo,' *like flowerets by the night frost.* 'Qual fior cadea sul lembo, qual sulle trecce bionde,' *some flowers fell on her lap, some on her fair tresses.*

The possessive adjective may be used for the possessive pronoun: 'Vostra mercè, cui tanto si commise,' *thanks to you, to whom so much was entrusted.*

The conjunctive pronoun is used instead of the possessive adjective when it refers to a part or limb of one's body: 'Mi duole il capo,' *my head aches.* 'Si ruppe il braccio,' *he broke his arm.*

In answering questions, the pronoun agrees, if it refers to a noun, with the definite article or demonstrative adjective: 'Siete voi le sorelle di quel signore? Sì, noi le siamo,' *are you the sisters of that gentleman? Yes, we are.* But if the answer refers to an adjective, verb, or noun without the definite article, the pronoun 'lo' is used: 'È essa arrivata? Sì, lo è,' *has she arrived? Yes, she has arrived.*

Personal pronouns should not be repeated before each verb in the same sentence: 'Io leggo, scrivo e parlo tutto il giorno,' *I read, write, and speak all day.*

Personal pronouns may be repeated with the same verb: 'E quel che tu fai tu, fo similmente,' *and that which you do, I do likewise.*

'Cui,' *him* or *her, them,* or *which.* Thus: 'O anima cortese mantovana, di cui la fama,' *O courteous Mantuan soul, of whom the fame.* 'Coloro, da cui erano stati assaliti,' *those by whom they had been attacked.*

Adjectives used as pronouns are:

alquanti, *some*	pochi, *few*
assai, *very many*	troppi, *too many*
molti, *many*	tutti, *all*
parecchi, *several*	

The most important Italian conjunctions are:

acciocchè, *in order that*	nonostante, *notwithstanding*
altresì, *besides, also*	nulladimeno, *nevertheless*
anche, *also*	o, *or*
anzichè, *rather than*	onde, *so that*
benchè, *although*	per altro, *however*
cioè, *that is*	perciò, *therefore*
come, *as*	però, *however*
dacchè, *since*	purchè, *provided*
dunque, *therefore*	pure, *also, yet*
e, *and* (before a vowel 'ed')	quand' anche, *even if*
eziandio, *also*	quantunque, *although*
finchè, *until*	se anche, *even if*
ma, *but*	sebbene, *although*
nè, *nor*	se, *if*
neppure, *not even*	tuttavia, *nevertheless*

Their use is explained in the following examples: 'Nella sala vi erano signori e signore,' *in the drawing-room there were ladies and gentlemen.* 'Incontrai una donna ed un uomo,' *I met a woman and a man.* 'Ella è tanto bella come buona,' *she is as beautiful as she is good.* 'Me ne ricorderò finchè vivo,' *I shall remember it as long as I live.* 'Il portalettere mi portò non solo otto lettere, ma anche due involti,' *the postman brought me not only eight letters, but also two packages.* 'Mi prestò il libro, onde lo leggessi,' *he lent me the book, so that I might read it.* 'Mi diede la nuova, acciocchè ne profittassi,' *he gave me the news, in order that I might profit by it.* 'Quand' anche mi promettesso restituirmelo, io non glielo presterei,' *even if he were to promise me to return it, I would not lend it to him.* 'Hai il giornale, dunque leggilo,' *you have the newspaper, therefore read it.* 'Lo leggerei, però non ho tempo,' *I would read it, but I have no time.* 'Non ho molto danaro, tuttavia gli presterò quanto mi domanda,' *I have not much money, nevertheless I shall lend him what he asks.* 'Queste sono quattro lire sterline, cioè cento lire italiane,' *these are four pounds sterling, that is one hundred Italian lire.* 'O vieni meco, o me ne vado solo,' *either come with me, or I shall go alone.* 'Se me le dessi, te lo restituirei,' *if you were to give it to me, I would return it to you.* 'Benchè (sebbene) sia ignorante, è ricco,' *although he is ignorant, he is rich.* 'Purchè lo voglia, glielo darò,' *provided he wants it, I shall give it to him.* 'Quantunque sia vecchio, ama divertirsi,' *although he is old, he likes to amuse himself.* 'Non glielo darò, nè per danaro, nè senza,' *I shall not give it to him, either for money, or without.* 'Sembra debole, pure è fortissimo,' *he looks weak, yet he is very strong.* 'Non lo farei neppure per sogno,' *I would not even dream of doing it.* 'Egli è mio parente, nulladimeno non ci parliamo,' *he is my relation, nevertheless we do not speak to each other.* 'Sono andato a trovarlo, ma egli non era a casa,' *I went to see him, but he was not at home.* 'La casa è non solamente grande, ma anche bella,' *the house is not only large, but also beautiful.* 'Nonostante la sua assenza prolungata, io non la dimenticherò mai,' *notwithstanding her prolonged absence, I shall never forget her.* 'Fu ucciso nella guerra, perciò la madre era addolorata,' *he was killed in the war, therefore his mother was sorrowful.* 'Ama molto la danza, per altro è studiosa,' *she is very fond of dancing, however she is studious.* 'Soffrirei tutto, anzichè rifiutarlo,' *I would suffer anything, rather than refuse him.* 'Dacchè sei qui, ti parlerò di quell' affare,' *since you are here, I will speak to you about that business.* 'Non lo prenderei, se anche me lo regalasse,' *I would not have it, even if he were to give it to me for nothing.*

Observe how nearly all conjunctions govern the verb in the subjunctive mood.

Interjections, as their name implies, are only exclamations, subject to no grammatical rule, and thus indeclinable. The most usual are:

affè, *indeed*	eh, ehi, *hallo*
ah, *ah*	evviva, *hurrah*
ahi, *helas*	fuori, *begone*
aiuto, *help*	guai, *woe*
all' erta, *on guard*	ohimè, *woe is me*
animo, *courage*	oibò, *fie*
avanti, *forward*	olà, *oh*
bene, *well*	orsù, *now then*
benone, *very well*	via, *away*
bravo, *well done*	zitto, *hush*
deh, *alas*	

'Bravo' and 'zitto,' real adjectives, may agree in gender and number with the noun they qualify.

'Aiuto, i ladri sono in casa,' *Help! thieves are in the house.* 'Affè, l' hai fatta bella,' *Indeed, you have put your foot in it.* 'All' erta, sentinella?' *What of the night, sentinel?* 'Avanti, prendiamo l' altra trincea,' *Forward, let us take the next trench.* 'Benone, il vostro esercizio è senza errori,' *Very well, your exercise has no mistake.* 'Guai ai nostri nemici,' *Woe to our enemies.* 'Oibò, non lo farei per nulla al mondo,' *Fie, I would not do it for anything in the world.* 'Orsù, partiamo, è mezzanotte,' *Now then, let us go, it is midnight.* 'Via, vattene,' *Away, be off with you.* 'Zitto, bambino, zitto,' *Hush, baby, hush.*

III

SOME USEFUL INFORMATION

Some figures of rhetoric in Italian:

alliteration	fra' diciotto e i diciannove (fradicio).
amphibology	aggirarsi *for* imbrogliarsi.
anaphora	Molto egli oprò col senno e con la mano Molto soffrì. . . .
antiphrasis	un omnibus veloce.
antonomasia	foglio *instead of* lettera.
apheresis	've *for* ove; stremo *for* estremo.
apocope	mi' *for* mio; maggio *for* maggiore.
battology	e non gli ha fatto male, non gli ha fatto.
chiasm	Ovidio è il terzo, e l' ultimo è Lucano.
diæresis	sorgono i vizi trionfando fuori.
ellipsis	andato a trovarlo, gli disse.
epenthesis	aghero *for* ago.
euphemism	s' approfittò *instead of* rubò.
hiatus	maestro, levaimi. . . .
hyperbaton	ci son restati uomini colti, che tu ti maraviglieresti.
hyperbole	infinità *instead of* gran numero.
idiotism	la peggio ruota del carro è quella che cigola.
metathesis	drento *for* dentro; isquatra *for* isquarta.
neologism	c' era tal fatta di merci.
onomatopœia	st *for* zitto.
paragoge	mene *for* me; tene *for* te.
pleonasm	a me mi pare; a te ti sta.
protasis	benchè molti la lodino, pochi l' amano.
prothesis	arricordarsi *for* ricordarsi.
sigla	ff. *instead of* facente funzione.
solecism	a riserva *for* salvo; fossimo *instead of* fummo.
syncope	opra *for* opera; cetra *for* cetera.
synecdoche	come da corda (*instead of* arco) cocca.
tautology	tra tre tremendi pericoli.
trope	due Soli *instead of* due occhi.

Some abbreviations:

Aff.	Affezionato.
Aff^mo	Affezionatissimo.
A.S.A.	A Sua Altezza.
A.S.E.	A Sua Eccellenza.
A.S.M.	A Sua Maestà.
C^mo	Carissimo

Col^{mo}	Colendissimo.
d.	devoto.
d.d.	devotissimo.
d.d.d.	devotissimo dedica.
D.	Don.
Dev.	Devoto.
Dev^{mo}	Devotissimo.
ecc.	eccetera.
M.	Messere.
Obb^{mo}	Obbedientissimo.
Obbl^{mo}	Obbligatissimo.
On.	Onorevole.
s.	san, santo.
S.	Servitore.
Sig.	Signore.
S^{ma}	Serenissima.
S.S.	Sua Santità.
V.S.	Vostra Signoria.
vs.	vostro.

Some notable contractions :

avestù *for* avesti tu, *had you.*
dammi *for* dà mi, *give me.*
danne *for* dà ne, *give us.*
dicci *for* di' ci (a noi), *tell us.*
diecci *for* diè *for* diede ci (a noi), *gave us.*
domattina *for* domani mattina, *to-morrow morning.*
egli *for* è gli, *to him is.*
emmi *for* è mi, *to me is.*
emmisi *for* è mi si, *to me it is.*
enne *for* è ne, *to us is.*
essene *for* è si ne, *of it he is.*
essi *for* è si, *to him is.*
etti *for* è ti, *to thee is.*
farestù *for* faresti tu, *would you do.*
fello *for* lo fe' (fece), *(he) did it.*
fessi *for* si fe' (fece), *to himself he did.*
folla *for* fo la, *(I) do it.*
fostù *for* fosti tu, *were you.*
gnorsì *for* signor, sì, *yes, sir.*
hacci *for* ha ci, *there is.*
hammi *for* ha mi, *to me has.*
havvi *for* ha vi, *there is.*
holla *for* ho la, *(I) have it.*
hollo *for* ho lo, *(I) have it.*
hottelo *for* ho ti lo, *(I) have to thee it.*
insennoe *for* e se no, *and if not.*
sommene *for* mi ne sono, *of it myself am.*
sommi *for* mi sono, *(I) am to me.*
sonci *for* ci sono, *there are.*
sonne *for* ne sono, *of it (I) am.*
sonsene *for* si ne sono, *of it they are.*
sta *for* questa, *only in* stamane, stamattina, stasera, stanotte.
starne *for* ne stare, *to be of it.*
stu *for* se tu, *if thou.*
tampoco *for* tanto poco, *not even.*
vacci *for* va ci, *go (you) there.*
vassene *for* si ne va, *goes away from here.*
vattene *for* va te ne, *go away from here.*
vomene *for* vo' (voglio) me ne, *(I) want of it myself.*
vommene *for* vo (vado) me ne, *(I) am going away from here.*
votti *for* ti vo' (voglio), *I wish to you.*

besides the numerous other contractions of the conjunctive pronoun.

Italian words only slightly different from their English equivalent :

abate, *abbot*
abbandonare, *to abandon*
abbietto, *abject*
abbominio, *abomination*
abbondanza, *abundance*
abbondare, *to abound*
accademia, *academy*
alla, *ell*
ammirabile, *admirable*
appartamento, *apartment*
appellare, *to appeal*
Appennini, *Apennines*
approvazione, *approbation*
Aragona, *Arragon*
architettura, *architecture*
astinenza, *abstinence*
aumentare, *to augment*
avversità, *adversity*

baldo, *bold*
balla, *bale*
bandito, *bandit*
bevero, *beaver*
bordo, *board*
bufalo, *buffalo*
buso, *boozy*

caffè, *coffee*
camozza, *chamois*
cappella, *chapel*
carattere, *character*
carota, *carrot*
cattedrale, *cathedral*
cattolico, *catholic*
cerimonia, *ceremony*
città, *city*
claretto, *claret*
coccodrillo, *crocodile*
cocolla, *cowl*
colazione, *collation*
colonnello, *colonel*
comandare, *to command*
comando, *command*
cominciare, *to commence*
commedia, *comedy*
comodità, *commodity*
comune, *common*
comunicare, *to communicate*
conforto, *comfort*
coraggio, *courage*
cotone, *cotton*
crespo, *crisp*

delfino, *dolphin*
difesa, *defence*
difficoltà, *difficulty*
dramma, *drama*
duetto, *duet*

eccellere, *to excel*
ecclissi, *eclipse*
entrare, *to enter*
eria, *eerie*
esagerare, *exaggerate*
esagerazione, *exaggeration*

fabbricazione, *fabrication*
femminino, *feminine*
fiaba, *fib*
flemma, *phlegm*
flussi, *flush (cards)*
fortuna, *fortune*
frale, *frail*
Federico, *Frederick*
fuggitivo, *fugitive*

galante, *gallant*
galea, *galley*
grancia, *grange*
grossa, *gross* (144)
grottesco, *grotesque*

ierarchia, *hierarchy*
immaginare, *to imagine*
immagine, *image*
incomodare, *to incommode*
infermo, *infirm*
ingombrato, *encumbered*
innamorato, *enamoured*

landa, *land (barren)*
lavanda, *lavender*
leggenda, *legend*
legittimo, *legitimate*
letteratura, *literature*
ligio, *liege*
littorale, *littoral*
lizza, *lists*
lucchetto, *locket*
lungo, *long*
lussuria, *luxury*

macchina, *machine*
malinconico, *melancholy*
maniera, *manner*
marittimo, *maritime*
materia, *matter*
meccanico, *mechanical*
mero, *mere*
milione, *million*
mucca, *muck*
musulmano, *Mussulman*

nobile, *noble*
nobiltà, *nobility*

obbediente, *obedient*
obbedienza, *obedience*
obbedire, *to obey*
obbligazione, *obligation*
obbrobrioso, *opprobrious*
Olanda, *Holland*
orizzonte, *horizon*
osservare, *to observe*
ostinato, *obstinate*

paggio, *page (boy)*
patriottico, *patriotic*
peltro, *pelter*
pianeta, *planet*
pittura, *picture*
proa, *prow*
profumo, *perfume*
provvedere, *to provide*
provvidenza, *providence*
provvisione, *provision*
pubblico, *public*

racchetta, *racket*
raccomandazione, *recommendation*
raccomandare, *to recommend*
reggente, *regent*
reggimento, *regiment*
ribellione, *rebellion*
riotta, *riot*

scellerato, *scelerate*
scirocco, *sirocco*
semplicità, *simplicity*
sepolcro, *sepulchre*
serio, *serious*
serraglio, *seraglio*
sicuro, *secure*
sidro, *cider*
sonetto, *sonnet*
spergiuro, *perjurer*
spettacolo, *spectacle*
spola, *spool*
sprazzo, *spray*
stampita, *stampede*
suscettibile, *susceptible*

tappezzeria, *tapestry*
tesoro, *treasure*
tollerare, *to tolerate*
tomba, *tomb*
trionfo, *triumph*
trippa, *tripe*

umiltà, *humility*

veemente, *vehement*
virtù, *virtue*
vittoria, *victory*
vittorioso, *victorious*

List of some idiomatic phrases :

aggrottare le sopracciglia, *to frown.*
a lungo andare, *in the long run.*
andare a sangue, *to like.*
andare a zonzo, *to stroll about.*
andare col calzare di piombo, *to go slowly.*
appigliarsi ad un partito, *to decide.*
arare diritto, *to behave well.*
avere cervello d' oca, *to be a fool.*
avere in tasca uno, *to dislike somebody.*
avere rotto lo scilinguagnolo, *to have the gift of the gab.*
aver a male, *to take offence.*
aver buona cera, *to look well.*
aver caldo, *to feel warm.*
aver cattiva cera, *to look ill.*
aver fame, *to be hungry.*
aver freddo, *to feel cold.*
aver fretta, *to be in a hurry.*
aver luogo, *to take place.*
aver ragione, *to be right.*
aver sete, *to be thirsty.*

aver torto, *to be wrong.*
averla con uno, *to be cross with someone.*
beccarsi l' esame, *to pass the examination by a fluke.*
bere a zinzini, *to sip.*
bere o affogare, *Hobson's choice.*
bugiardo come un epitaffio, *as liar as a tombstone.*
cacciarsi le mosche dal naso, *to have one's way.*
cadere dalla padella nella bracia, *to fall from the frying-pan into the fire.*
cercare il nodo nei giunchi, *to look for troubles.*
cercare il pelo nell' uovo, *to look for troubles.*
chi sa chi, *God knows who.*
dar a intender lucciole per lanterne, *to deceive.*
dar causa vinta, *to cave in.*
dar mano forte, *to help.*
dar mente, *to heed.*
dare agio, *to give a chance.*
dare di frego, *to wipe off.*
dare fondo, *to run through (money).*
dare incenso ai morti, *to waste one's work.*
dare in sulla voce, *to scold.*
dare un pugno al cielo, *to attempt the impossible.*
darsi la zappa sui piedi, *to put your foot in it.*
dire al pan, pane, *to call a spade a spade.*
esser pane e cacio con uno, *to be intimate friends.*
essere a cavallo, *to have succeeded.*
essere all' ordine, *to be ready.*
essere al verde, *to be beggared.*
essere in cattive acque, *to be in trouble.*
essere in ritardo, *to be late* (of persons).
essere nato vestito, *to be lucky.*
essere per, *to be on the point of.*
essere tardi, *to be late* (of time).
essere un peccato, *to be a pity.*
facile come bere un uovo, *very easy.*
far alto e basso, *to lord it over.*
far capitale di uno, *to rely on someone.*
far capolino, *to peep.*
far fagotto, *to pack up.*
fare a gara, *to compete.*
fare allungare il collo ad uno, *to keep somebody waiting.*
fare a mezzo, *to go shares.*
fare civetta, *to duck one's head.*
fare diciotto con tre dadi, *to be very lucky.*
fare festa ad uno, *to welcome somebody.*
fare fiasco, *to fail.*
fare furore, *to carry the public by storm.*
fare i conti senza l' oste, *to reckon wrongly.*
fare il mogio, *to lie low.*
fare la festa ad uno, *to kill someone.*
fare la posta, *to watch.*
fare largo, *to make room.*
fare le viste, *to make-believe.*
fare l' orecchie del mercante, *to pretend not to hear.*
fare spalle, *to support.*
fare spallucce, *to shrug one's shoulders.*
fare tempo, *to give credit.*
fare una frittata, *to make a mistake.*
fare un buco nell' acqua, *to waste one's time.*
fare un viaggio e due servizi, *to kill two birds with one stone.*
farsi onore del sole di luglio, *to boast wrongfully.*
filo per filo, *exactly.*
franco di porto, *carriage paid.*
giocare un mal tiro, *to play a bad trick.*
guardare in cagnesco, *to scowl.*
il fare del dì, *the break of day.*
impattarla con uno, *to get even with somebody.*
in capelli, *bareheaded.*
in fretta e in furia, *with a rush.*
in tutto e per tutto, *altogether.*
in un attimo, *in a twinkling.*
io come io, *as for me.*
legarsela al dito, *to make a note of it.*
levarsi da torno, *to get rid of.*
libro del quaranta, *pack of cards.*
libro maestro, *ledger.*
macinino da caffè, *coffee-mill.*
maestro di casa, *butler.*
mala parata, *bad look-out.*
mandare a quel paese, *to send to Bath.*
man mano, *gradually.*
marea alta, marea bassa, *high tide, low tide.*
menare in lungo, *to drag a long while.*
mettere a repentaglio, *to endanger.*
mettere il nero sul bianco, *to write.*
mettere in mezzo, *to deceive.*
mettere in sesto, *to make things tidy.*
mettere tempo in mezzo, *to delay.*
mettere troppa carne al fuoco, *to have too many irons in the fire.*
mettersi la via tra le gambe, *to start.*
moneta spicciola, *small change.*
mostrare la luna nel pozzo, *to deceive.*
non far nè caldo nè freddo, *to be indifferent.*
non mangiare d' una cosa, *not to understand a thing.*
non sapere ove dar di capo, *not to know what to do.*
non veder l' ora, *to long for.*
pagarla salata, *to pay dearly.*
pane di Spagna, *sponge-cake.*
peggio che peggio, *worse than ever.*
pelle pelle, *skin-deep.*
per dato e fatto di, *because of.*
per diritto e per traverso, *by hook or by crook.*
per farla corta, *to make a long story short.*
per giunta, *into the bargain.*
pescare nel torbido, *to fish in troubled waters.*
pestare l' acqua nel mortaio, *to waste one's labour.*
pieno zeppo, *chokefull.*
pigliar cappello, *to take offence.*
pigliare commiato, *to take leave.*
pigliare il sopravvento, *to take the upper hand.*
pigliare un granchio, *to be mistaken.*
più lungo d' un dì senza pane, *very long (time).*
porre mente, *to heed.*
portar civette ad Atene, *to carry coals to Newcastle.*
pulito come un dado, *very clean.*
quando mai, *if ever.*
quanto mai, *ever so much.*
questo poi, *as for this.*
qui sta il busillis, *here is the rub.*
rendere pan per focaccia, *to give tit for tat.*
restare con un palmo di naso, *to be fooled.*
rimanere con le mosche in mano, *to be left fooled.*
saltare di palo in frasca, *to wander from one to another subject.*
sano come un pesce, *very healthy.*
sano e salvo, *safe and sound.*
scrivere come una gallina, *to write a very bad hand.*
se non se, *but.*
seta cangiante, *shot-silk.*
sganasciarsi dalle risa, *to laugh immoderately.*
spillatico, *pin-money.*
stare a bada, *to wait.*
stare a stecchetto, *to be on short commons.*
stare a tu per tu, *to be on equal terms.*
stare bene ad uno, *to serve him right.*
stare colle mani in mano, *to be idle.*
stare fresco, *to be in a sorry plight.*
stare sopra le spine, *to be on tenterhooks.*
stare sulle sue, *to stand on one's dignity.*
stillarsi il cervello, *to rack one's brains.*
stringersi nelle spalle, *to shrug one's shoulders.*
tal dei tali, *so and so.*
tale quale, *like.*
tanto quanto, *somehow.*
tenere il piede in due staffe, *to run with the hare and chase with the hounds.*
tenere le mani in pasta, *to have a finger in the pie.*
tener mano, *to help.*
testatico, *poll-tax.*
tirare giù a refe doppio, *to exaggerate.*
toccare il cielo col dito, *to be very happy.*
tornare a bomba, *to return to the subject.*
trarre partito da, *to profit by.*
trovarsi nelle male peste, *to be in a bad plight.*
tutt' affatto, *altogether.*
tutto altro che, *anything but.*
tutto che, *although*
una muta di cani, *a pack of hounds.*
uscire dai gangheri, *to lose patience.*
uscire fuori del seminato, *to wander from the subject.*
vendere gatta in sacco, *to sell a pig in a bag.*
vendere lucciole per lanterne, *to deceive.*
venir fatto, *to succeed.*
venir l' aquolina in bocca, *to make one's mouth water.*
venir la pelle d' oca, *to shiver.*
venire la palla al balzo, *to get the chance.*
via scorciatoia, a *short-cut.*
volesse il Cielo, *would to Heaven.*

Some English proverbs with their Italian equivalents.

The rich man has always plenty of friends.
Abbi pur fiorini, che troverai cugini.

A wise man is seldom wrong.
A ben s' appiglia, chi ben si consiglia.

Where there is a will, there is a way.
A buona volontà, non manca facoltà.

A word is enough to the wise.
A buon intenditor, poche parole.

A bad workman dislikes his tools.
A cattivo zappatore, ogni zappa gli è pesore.

Do not look a gift horse in the mouth.
A caval donato non si guarda in bocca.

To give advice is always very easy.
A chi consiglia, non duole il capo.

Hunger is the best sauce.
A chi è affamato, ogni cibo è grato.

The evil-doer never prospers.
A chi mal fa, mal va.

Still waters run deep.
Acqua cheta rovina i ponti.

A lost opportunity never returns.
Acqua passata non macina mulino.

Love is blind.
Affezione accieca ragione.

Charity begins at home.
Aiuta i tuoi, e gli altri se tu puoi.

A friend in need is a friend indeed.
Al bisogno si conosce l' amico.

A servant needs patience, whilst his master needs prudence.
Al servo pazienza, al padrone prudenza.

God's love is our best guide.
Ama Dio, e non fallire.

Faint heart never won fair lady.
Amante non sia, chi coraggio non ha.

Even a worm will turn.
Anche la mosca ha la sua collera.

Build a golden bridge for a flying enemy.
A nemico che fugge, ponte d' oro.

There is no place like home.
A ogni uccello, suo nido è bello.

Every little makes a mickle.
A quattrino a quattrino, si fa il fiorino.

Enough is as good as a feast.
Assai è ricco a chi non manca.

Speech is silvern, silence golden.
Assai sa chi non sa se tacer sa.

He calls the tune who pays the piper.
Attacca l' asino dove vuole il padrone.

Strike the iron when hot.
Batti il chiodo quando è caldo.

What cannot be cured must be endured.
Bisogna fare di necessità virtù.

Live, and let live.
Bisogna vivere, e lasciar vivere.

Good wine needs no bush.
Buon vino non vuol frasca.

A barking dog does not bite.
Can che abbaia non morde.

There is no place like home.
Casa mia, casa mia,
Per piccina che tu sia,
Tu mi sembri una badia.

Love me, love my dog.
Chi ama me, ama il mio cane.

He who seeks, finds.
Chi cerca trova, e chi dorme non piglia pesci.

Forewarned, forearmed.
Chi è avvisato, è armato.

Give a dog a bad name, and then hang him.
Chi è diffamato, è mezzo impiccato.

Marry in haste, repent at leisure.
Chi erra in fretta, piange adagio.

The best help is self-help.
Chi fa per sè, fa per tre.

More haste, less speed.
Chi ha fretta, indugi.

Health is wealth.
Chi ha la sanità, è ricco e non lo sa.

Do not put off till to-morrow what can be done to-day.
Chi ha tempo, non aspetti tempo.

Sow the wind, and reap the whirlwind.
Chi mal semina, mal raccoglie.

The leopard cannot change its spots.
Chi nasce lupo, non muore agnello.

Look before you leap.
Chi non guarda, non vede.

Nothing venture, nothing gain.
Chi non risica, non rosica.

Grasp all, lose all.
Chi più abbraccia, meno stringe.

First come, first served.
Chi prima arriva, prima macina.

God helps those who help themselves.
Chi s' aiuta, Dio l' aiuta.

Slow and sure.
Chi va piano, va sano e va lontano.

With nothing, nothing is done.
Col nulla non si fa nulla.

Everything comes to those who wait.
Col tempo e colla paglia si maturano le nespole.

Short accounts make good friends.
Conti spessi, amicizia lunga.

Forewarned, forearmed.
Cosa prevista, mezza provvista.

May God protect me from those I trust,
For I shall guard myself from those I mistrust.
Dai miei amici mi guardi Dio,
Chè dai nemici mi guarderò io.

There is many a slip between the cup and the lip.
Dal detto al fatto, c' è un gran tratto.

Knowledge is wealth.
Dal sapere vien l' avere.

A man is known by the company he keeps.
Dimmi con chi tu vai, e ti dirò che fai.

There is no smoke without fire.
Non c' è fuoco senza fumo.

Do your duty and shame the devil.
Fa il dovere, e non temere.

Murder will out.
Gran peccato non può star celato.

Good wine needs no bush.
Il buon vino non ha bisogno di frasca.

The devil is not so black as he is painted.
Il diavolo non è brutto quanto si dipinge.

To lose time grieves most those who know most.
Il perder tempo a chi più sa più spiace.

Far from sight, far from mind.
Lontan dagli occhi, lontan dal cuore.

Appetite is the best sauce.
L' appetito non vuol salsa.

Misfortunes never come alone.
Le disgrazie non vengono mai sole.

The idle man is always in need.
L' ozioso è sempre bisognoso.

Man proposes, and God disposes.
L' uomo propone, e Dio dispone.

A bird in the hand is worth two in the bush.
Meglio un uovo oggi che una gallina domani.

It is not all gold that glitters.
Non è tutt' oro quel che riluce.

Every dog has its day.
Ogni granchio ha la sua luna.

There is no rose without thorn.
Ogni rosa ha la sua spina.

Do in Rome as the Romans do.
Ovunque vai, fa come vedrai.

Speech is silvern, silence golden.
Parla poco e ascolta assai,
E giammai non fallirai.

Penny saved, penny gained.
Quattrino risparmiato, quattrino guadagnato.

A rolling stone gathers no moss.
Sasso che non sta fermo, non vi si ferman mosche.

Different meanings of words :

abitato, *inhabited*	vestito, *dressed*
abusare, *to abuse*	biasimare, *to blame*
accanto, *by the side*	accosto, *close*
accentare, *to put an accent*	accentuare, *to put the stress*
acuto, *sharp*	aguzzo, *pointed*
adatto, *apt*	addato, *aware, used to*
affittare, *to let (land)*	appigionare, *to let (house)*
agro (n.), *land*	agro (adj.), *sour*
aio, *tutor*	tutore, *guardian*
albero, *tree*	alberello, *phial*
allora, *then*	alloro, *laurel*
amo, *fish-hook*	amo, *I love*
anima, *soul*	animo, *courage*
appiccare, *to hang up*	impiccare, *to hang (a man)*
appresso, *afterwards*	presso, *near*
ardere, *to burn*	ardire, *to dare*
assorbito, *absorbed*	assorto, *enrapt*
astratto, *abstract*	distratto, *distracted*
attimo, *smallest amount of time*	atomo, *smallest amount of matter*
avanti, *before* (time)	davanti, *before* (place)
avvisare, *to warn*	consigliare, *to advise*
baffuto, *with mustachios*	paffuto, *puffy*
balla, *bale*	palla, *ball*
balena, *whale*	baleno, *lightning*
banda, *band*	bando, *proclamation, banishment*
baro, *card-sharper*	barone, *baron*
battaglia, *battle*	battaglio, *bell-clapper*
battere, *to beat*	combattere, *to fight*
bocca, *mouth*	boccia, *flask*
bicchiere, *glass (drinking)*	vetro, *glass (pane)*
bisogna, *business*	bisogno, *want*
boia, *hangman*	buoi, *oxen*
braccio, *arm*	bracco, *hound*
breve, *short (time)*	corto, *short (space)*
busta, *envelope*	busto, *corset, bust*
caffettiera, *coffee-pot*	caffettiere, *coffee-house keeper*
calle, *lane*	callo, *corn*
canape, *tow*	canapo, *rope*
capello, *hair*	cappello, *hat*
capitale (m.) *capital (money)*	calitale (f.), *capital (city)*
carica, *office*	carico, *laden*
cattività, *captivity*	cattiveria, *wickedness*
cavalletta, *locust*	cavalletto, *easel*
cavallo, *horse*	cavaliere, *knight*
celibe, *bachelor*	nubile, *spinster*
cera, *wax*	cero, *taper*
chiave, *key*	chiavistello, *lock*
ciglio, *eyebrow*	cipiglio, *frown*
colle, *hill*	collo, *neck*
colpa, *fault*	colpo, *blow*
condotta, *behaviour*	condotto, *drain*
consiglio, *advice*	concilio, *council, ecclesiastical*
contadino, *peasant*	concittadino, *fellow-citizen*
contesa, *quarrel*	contessa, *countess*
copia, *copy*	coppia, *couple*
corte, *court*	cortile, *courtyard*
corsa, *race (horse)*	corso, *racecourse*
costa, *coast*	costo, *cost*
curato, *parson*	vicario, *curate*
deforme, *deform*	difforme, *different*
dianzi, *before* (time)	dinanzi, *before* (place)
difendere, *to defend*	proibire, *to forbid*
dipoi, *afterwards*	dopo, *since*
dire, *to say*	parlare, *to speak*
distogliere, *to distract*	divertire, *to amuse*
divisa, *uniform*	diviso, *separated*
doglia, *pain*	doglio, *mourning*
donna, *woman*	donno, *master*
duca, *duke*	duce, *leader*
esibizione, *offer*	esposisizione, *exhibition*
esule, *exile (an)*	esile, *thin*
fallare, *to be mistaken*	fallire, *to fail*
fallo, *fault*	falò, *bonfire*
fama, *fame*	fame, *hunger*
famiglia, *family*	famiglio, *stableman*
fascia, *scarf*	fascio, *bundle*
fascina, *bundle of firewood*	fascino, *fascination*
fata (la), *fairy*	fato (il), *fate*
finchè, *until*	affinchè, *in order that*
fine (il), *aim*	fine (la), *end*
fiocco, *tassel*	fiacco, *feeble*
fiutare, *to smell*	rifiutare, *to refuse*
foglia, *leaf*	foglio, *sheet of paper*
folla, *crowd*	fola, *fib*
fossa, *grave*	fosso, *ditch*
freddo, *cold*	freddare, *to kill*
fugare, *to rout*	trafugare, *to hide*
fuggire, *to run away*	sfuggire, *to avoid*
genitore, *parent*	parente, *relation*
germano, *brother*	Tedesco, *German*
ghiro, *dormouse*	giro, *tour*
giocare, *to play*	sonare, *to play* (*music*)
giubba, *jacket*	giuba, *lion's mane*
gogna, *the stocks*	agognare, *to long for*
grazia, *favour*	grazie, *thanks*
gridare, *to shout*	sgridare, *to scold*
inabitato, *disinhabited*	abitato, *inhabited*
incendio, *conflagration*	fuoco, *fire*
ingegno, *cleverness*	genio, *genius*
in grazia di, *thanks to*	di grazia, *please*
lagnarsi, *to complain*	compiangere, *to pity*
lampa, *lamp*	lampo, *lightning*
latta, *zinc*	latte, *milk*
legato, *legacy*	retaggio, *inheritance*

lente, *lens*	lentigine, *lentil*
levare, *to take off*	sollevare, *to lift*
libbra, *pound (weight)*	libro, *book*
librare, *to poise*	liberare, *to liberate*
lima, *file*	limo, *slime*
lode, *praise*	lodo, *award*
lordo, *dirty*	pesante, *heavy*
loto, *mud*	lotto, *lottery*
lotta, *struggle*	lotto, *lottery*
luce, *light (sun)*	lume, *light (candle)*
lungo, *along*	lungi, *afar*
lusso, *luxury*	lussuria, *lust*
maestro, *teacher*	padrone, *master*
maestro di casa, *butler*	padrone di casa, *master*
mane, *morning*	mano, *hand*
manica, *sleeve*	manico, *handle*
marcia, *march*	marcio, *rotten*
matto, *mad*	mattone, *brick*
mazza, *mace*	mazzo, *bunch*
mente, *mind*	mento, *chin*
meridiano, *meridian*	meridionale, *southern*
mese, *month*	messe, *harvest*
messa, *mass*	messe, *harvest*
meta, *goal*	metà, *half*
mezzo, *half*	mezzo, *over-ripe*
miglio, *mile*	miglio, *millet*
mina, *mine (military)*	miniera, *mine (gold, &c.)*
mirare, *to stare*	ammirare, *to admire*
misero, *miserable*	avaro, *miser*
moda, *fashion*	modo, *manner*
mola, *mole*	molo, *jetty*
mondo, *world*	mondo, *clean*
mota, *mud*	moto, *movement*
nanna, *lullaby*	nonno, *grandfather*
nei, *in the*	nei, *beauty-spots*
notare, *to note*	notare, *to swim*
onda, *wave*	ònde, *therefore*
opposto, *opposed*	in faccia, *opposite*
ora, *hour*	ora, *now*
orbe, *world*	orbo, *blind*
orza, *weather-side*	orzo, *barley*
ostrica, *oyster*	struzzolo, *ostrich*
palma, *palm*	palmo, *span*
pani, *loaves*	panni, *clothes*
passaggio, *passage*	passeggio, *promenade*
pasta, *dough*	pasto, *repast*
patto, *condition*	compatto, *agreement*
pedata, *kick*	spedato, *foot-sore*
pelo, *hair*	pelle, *skin*
pesca, *fishing*	pesca, *peach*
pezza, *piece of cloth*	pezzo, *piece*
piaggia, *shore*	piaggiare, *to flatter*
pianta, *plant*	pianto, *weeping*
poli, *poles*	Polacchi, *Poles*
poltrona, *couch*	poltrone, *coward*
pondo, *weight*	ponte, *bridge*
porta, *door*	porto, *port*
potere, *power*	podere, *estate*
proda, *shore*	prode, *brave*
prodigio, *prodigy*	prodigo, *prodigal*
progettare, *to plan*	sporgere, *to project*
proposta, *proposal*	proposito, *purpose*
pupilla, *eyelid*	pupillo, *pupil*
putare, *to lop*	reputare, *to repute*
querela, *complaint*	rissa, *quarrel*
raccolta, *collection*	raccolto, *harvest*
racconto, *tale*	conto, *account*
ragna, *spider's web*	ragno, *spider*
razza, *race*	razzo, *rocket*
revocare, *to annul*	rievocare, *to recall*
ricantare, *to sing again*	ridirsi, *to recant*
ricetta, *prescription*	ricetto, *shelter*
riva, *shore*	rivo, *river*
rivenire, *to return*	rinvenire, *to find again*
roba, *property*	veste, *dress*
romanza, *song*	romanzo, *novel*
saetta, *thunderbolt*	setta, *sect*
sala, *drawing-room*	sale, *salt*
saldare, *to pay off*	soldare, *to enlist*
salute, *health*	saluto, *greeting*
scolta, *scout*	scorta, *escort*
scopa, *broom*	scopo, *purpose*
scritta, *contract*	scritto, *written*
seno, *bosom*	senno, *wisdom*
seta, *silk*	sete, *thirst*
sfaccendato, *idle*	sfacciato, *barefaced*
sogno, *dream*	sonno, *sleep*
soma, *load*	somma, *sum*
sparito, *disappeared*	sparuto, *sickly*
speciale, *special*	speziale, *chemist*
specie, *species*	spezie, *spices*
spilla, *pin*	spillatico, *pin-money*
statico, *hostage*	testatico, *poll-tax*
stile, *stile*	stilo, *graver*
strano, *strange*	straniero, *foreigner*
suddito, *subject of a king*	soggetto, *subject-matter*
suola, *sole (boot)*	suolo, *soil*
tacco, *heel*	tacchino, *turkey*
taglia, *ransom*	taglio, *cut*
tagliare, *to cut*	taglieggiare, *to blackmail*
tela, *linen*	telo, *arrow*
testa, *head*	testo, *text*
tornare, *to return*	volgersi, *to turn*
tufo, *tufa*	tuffo, *plunge*
udire, *to hear*	intendere, *to understand*
urtare, *to push*	far male, *to hurt*
valle, *valley*	vallo, *rampart*
vela, *sail*	velo, *veil*
velo, *veil*	vello, *fleece*
ver (vero), *true*	vêr (verso), *towards*
verso, *line of poetry*	stanza, *verse*
vita, *life*	vite, *vine, screw*
vo, *(I) go*	vo', *(I) wish*
volare, *to fly*	involare, *to steal*
volta, *time*	volto, *face*
voto, *vow*	vuoto, *empty*
zappa, *spade*	spada, *sword*
zucchero, *sugar*	sughero, *cork*

Some verbs which appropriately express the actions of animals :

L' asino raglia.
Il bue mugghia, muglia, muggisce.
Il cane abbaia, latra, guaisce, ringhia, scodinzola, uggiola.
Il cavallo nitrisce, scalpita.
Il corvo gracchia.
L' elefante barrisce.
Il falco strido.
La gallina croccia, chiocciola, gracida, pigola, ruspa, ruzzola, schiamazza, starnazza.
Il gallo canta.
Il gatto miagola, gnaula.
L' insetto ronza, pinza.
Il leone ruggisce.
Il lupo ulula, urla.
La mosca ronza.
L' oca grida.
Il pappagallo squittisce.
La pecora bela, bruca.
Il pesce guizza.
Il pipistrello zirla.
Il porco grugnisce.
La rana gracchia, gracita.
La scimmia grida.
La serpe sibila.
L' uccello canta, garrisce, cinguetta.
L' uomo parla.
Il vento tira, trae, spira, poggia.

Pollice, *thumb ;* indico, *first finger ;* medio, *second finger ;* anulare, *third finger ;* mignolo, *little finger.*

IV

SIX CENTURIES OF ITALIAN LITERATURE

At the beginning of this sketch we have endeavoured to explain how the Italian language was gradually developed from the Latin, in the

course of many centuries, until it reached its highest perfection in the writings of Dante. After the Trecento (1275–1375) there was a period of nearly a century, during which took place a certain revival of Latin and Greek studies almost everywhere throughout Italy. The fall of Constantinople, which brought to Italy numberless refugees with an immense number of Greek manuscripts, contributed powerfully to this revival. During this period, named the Quattrocento (1375–1475), hardly any important work was written in Italian, the learned men having resumed the expression of their ideas in the Latin language, which they wrongfully believed to be a better medium of diffusing knowledge than the Italian, unmindful of the fact that by the use of Latin they limited to a small circle of men truths which would otherwise have reached a far larger number of readers.

Some minor but more popular writers continued, however, the work of the Trecento, by their chronicles, short stories, imaginary lives of saints, and books of travel. Among those who wrote in Italian were Agnolo Pandolfini, Leon Battista Alberti (the earliest writer on fine arts), Luigi Pulci (the great humorist), Angelo Poliziano, and Lorenzo de' Medici.

It was, however, in the glorious Cinquecento (1475–1575) that Italian literature and Italian fine arts reached their highest point of greatness and refinement. The art of printing was then spread nearly everywhere in Italy, Aldo Manuzio having brought it at Venice to a perfection that was never surpassed in later times. Naturally this contributed wonderfully to the general diffusion of knowledge.

In Michelangelo (1475–1564), Leonardo (1452–1519), Benvenuto Cellini (1500–1570) and Vasari (1512–1574), we find the most wonderful examples of the rare union of literature and art in the same great men, and in the highest perfection.

Michelangelo's poetry, especially the sonnets to Vittoria Colonna, the gifted widow of the Marquis of Pescara, Commander-in-Chief of the troops of the Emperor Charles V in Italy and hero of the battle of Pavia, in which he made prisoner Francis I, King of France, are full of sweet tenderness as well as of platonic love, and bear comparison with the best of Petrarca. His private correspondence, which fills two large volumes, gives us a correct insight into the private lives of the artists and statesmen of that time.

Leonardo's *Trattato della Pittura* is an invaluable and very useful work on the art of painting, and is among the best classics of the Italian literature.

Benvenuto Cellini wrote his *Vita*, the best autobiography ever written in any language, which has been translated into German by Goethe, and into English by Roscoe. There is no more entertaining book, nor any which shows more vividly the daily life of artists in the sixteenth century. It has, moreover, the merit of telling the truth, even when the truth is to the disadvantage of the writer. His days at the French Court of Francis I are full of interesting political information and Court scandal.

To Giorgio Vasari, the gifted author of the *Lives of the Painters and Sculptors of the Renaissance*, we are indebted for all we know about those artists, with whom the author was personally acquainted, and whose works he discusses as an artist. Modern writers have criticised Vasari's *Lives* as those of a gossip, whilst getting from them all the real information, of which they avail themselves so freely. As a contemporary writer, and one who knew the people of whom he was writing and their artistic works, Vasari has this advantage over every other biographer of the artists of the Italian Renaissance; and since his time everyone who has endeavoured to write about them has been an ungrateful plagiarist of his biographies. Foremost among these, and most notorious, have been the German writers, who in this branch of human knowledge, as in every other, have assumed a superiority, the only foundation for which is to be found in their own presumption. The only relation which Huns have to the fine arts being that which is fully acknowledged by the civilised nations of the world, and to which their wars bear witness, being that of destroyers or looters.

Machiavelli (1469–1527), the greatest prose writer of all ages in Italy, united to the beauty of his style the deepest knowledge of the philosophy of history and statecraft, and his works have been translated into all modern languages. Guicciardini (1482–1540) was an historian of sterling literary merit. Ariosto (1474–1533) is, after Dante, the greatest Italian poet, whose imagination has hardly a rival in any other literature. He was also a great master of style, the artistic simplicity of which adds to the reading of his immortal poem pleasures hardly found in the reading of Dante. It is enough to state that, although written four centuries ago, there is not in the immense length of the *Orlando Furioso* a single word which could be called obsolete, or not be understood by any educated Italian of to-day. At the head of all Italian humoristic poets stands Berni (1497–1535), who even gave his name to this kind of poetry, called "bernesca." If he has any rival in other literatures, they can only be found among the American humorists of modern times. With all this, he is also a very refined writer, whose deep knowledge of the language can only be compared to the perfection of his style. Thus he has become one of the most popular writers among the Italian classics.

If the style of Machiavelli is perfect in its

force and clearness, that of Agnolo Firenzuola (1493–1548) is unsurpassed for its charm and wealth. His works are a mine from which all the purest and sweetest words of the language can be got with the least trouble and with the greatest pleasure. His prose is the most entertaining which is to be found in Italian literature.

This period in the history of Italy was not only glorious for the excellence of its literature. The fine arts reached in that country their highest perfection in the modern world; and no comparison can be made of their immortal works to any others than to those of Greece.

Hellenic art, the most glorious plastic manifestation of the human mind, began to decay after the fall of Hellenic independence. Under the Roman Empire this decay was slow but steady; and during the Dark Ages that followed the fall of the Roman Empire, under the Greek emperors, we find it transformed into what is called Byzantine art, which was only a dim and distorted recollection—often a mechanical reproduction—of the only plastic expression of the human mind, until in the thirteenth century the Italian Renaissance burst forth with Niccola and Giovanni Pisani, Arnolfo di Lapo, Cimabue and Giotto, the giants who mostly contributed to free mankind from the monstrous darkness of the Middle Ages. These were the men who first, with the breath of their genius, breathed life into the dead forms of the plastic arts; and, as Lord Lindsay said, "Whatever of highest excellence has been achieved in sculpture, architecture, and painting, not only in Italy, but throughout Europe, has been in obedience to the impulse they primarily gave." This awakening was not limited to architecture, sculpture, and painting. A religious upheaval was also taking place; and the Crusades had contributed their share to it. At the same time there was created in Italy a new language, which could vie with that of Greece in its beauty, and which found in Dante its greatest writer. Philosophy also began the struggle to free itself from the bonds of scholasticism, whilst Guido d' Arezzo found for music a universal language.

The awakening of the Italian people to their civil rights had preceded for some time this period, when the republics of Venice, Genoa, Pisa, and Amalfi were the most flourishing of European States. Some of the immense wealth which they accumulated was liberally spent in the foundation of hospitals and libraries, and in the building of cathedrals and town halls, which to this very day are standing monuments of the high point of progress and civilisation reached in some parts of Italy in the thirteenth century.

As in classical Greece, so in Italy at this time of the Renaissance, artists did not trouble themselves with the modern problem whether art should limit its scope to the "imitation" of Nature or extend it to its "interpretation." They were quite satisfied with following and imitating Nature as closely as possible. This idea was expressed very plainly and clearly by Dante, the great friend of Giotto, in the words:

> "Philosophy," he said, "to him who heeds it,
> Noteth, not only in one place alone,
> After what manner Nature takes her course
> From Intellect Divine, and from its art;
> And if thy Physics carefully thou notest,
> After not many pages shalt thou find,
> That this your art as far as possible
> Follows, as the disciple doth the master;
> So that your art is, as it were, God's grandchild."
> (Longfellow's translation, *Inferno*, c. XI.)

In Greece the ideal of personal beauty was wholly physical. Their academies, their schools, and their games led to a life mostly passed out of doors; and the populace of Athens sat and witnessed the gorgeous spectacles of their theatre under the blue sky of Greece, with the sunlight glinting on the snowy marbles of the vast proscenium. This out-of-door life produced results in the purely physical ideals of strength, symmetry, &c., more in men than in women; and so it came to pass that their Apollo was far superior to their Aphrodites.

Though the Romans attributed more beauty to woman, they did not limit it to their face only. The very word for beauty was "forma," implying perfection in the whole person.

Before the Renaissance, woman had never been acknowledged as the equal of man. To lift woman to the same level as man was the silent work of thirteen centuries of Christianism. The worship of the mother of Christ, in its very exaggeration, aided by the ages of chivalry, of the Crusades, of the troubadours, and by the great Italian poet, who was able to write of her: "Woman, through whom alone mankind enjoys the highest bliss in that part of heaven nearest to God" (*Inferno*, c. II), all contributed to it. Thus modern art acknowledged in woman the ideal of beauty, whether she be portrayed as a Madonna or as La Gioconda. In this new ideal the physical beauty is tempered and purified by the spiritual. Force and "forma" gave way to loveliness and charm. The ideal of beauty passed gradually from the masculine to the feminine type. To these qualities the face is the true index; and hence woman's face—its features and expression—are held as the first and most important test of beauty.

The faces limned by the Italian painters, though they may have lost the faultless regularity or the masculine severity of those of the Greeks, have gained in their new womanhood a wistful, appealing, mystical look, eloquent evidence of the higher position to which woman had been raised. As late as Botticelli, this type of beauty and this conception of it are supreme in Italian art, and the exquisite creations of that painter give the most perfect and the most wonderful expression to ideal loveliness, radiant in a glory which is almost divine.

In some of the Italian painters of the Renaissance we see a temporary reversion to the Græco-Roman theories of beauty—as, for example, in Titian, who set off the female form with all the splendour of that master's marvellous colouring and unequalled voluptuousness. This return to older forms of beauty is still more prominent later on, in the strapping Flemish beauties so frequent on the canvases of Rubens.

The tendency of subordinating the purely physical to the intellectual and emotional has gone on progressing to such a point that nowadays it is almost wholly in the face that the highest possible ideal of pure loveliness is supposed to lie.

Torquato Tasso (1544–1595) may be considered either as the last poet of the Cinquecento or the first of the Seicento (1575–1675). His poem *Gerusalemme liberata* is still very popular, and its religious subject endears it to the majority of Italians. Its style is very simple and clear; and the episodes by which it is filled are pleasant and emotional. His genius and his works are not, however, to be compared to those of Dante. or even Ariosto's; and he is correctly described as the first poet of the Italian Decadence, or the Seicento (1575–1675). He lived the most miserable and most romantic life of any poet; and of him there remain five big volumes of letters, in which he complained of his hard fate. But he has left us a real literary gem in his pastoral drama, the *Aminta*, the most beautiful in Italian literature. Chiabrera (1552–1637), a minor poet, is remarkable for the simplicity and purity of his diction. But he was, though unconsciously, the forerunner of those silly Arcadians, who made Italian poetry ridiculous in the following generation. Filicaia (1642–1707) will ever be popular in Italy for his famous and well-known sonnet *All' Italia*, translated into English by Byron. Guarini (1538–1612) is recorded as the earliest of the Secentisti, punsters and exaggerators of the oncoming decadence of the Italian literature.

Among these writers of the Seicento shines brightly the famous name of Galileo Galilei (1564–1642), who, however, owes his immortal renown to his scientific genius rather than to his literary work. The Inquisition was at the time all-powerful in the small Italian States, where it stifled every expression of truth distasteful to the Papal Court. Among its victims are to be remembered, besides Galileo, other great and well-known enemies of Popery: Giordano Bruno (1550–1600), Campanella (1568–1639), Vannini (1535–1619), and Gelesio—philosophers and theologians of note, whose works had the honour of being placed in the Roman Index of Forbidden Books.

It was in 1690 that the Academy of the Arcadians was founded in Rome, where it still flourishes. It pretended to represent the literary life of Italy, and was instead the most ridiculous association of literary nobodies ever assembled. Each member was only known by a pastoral nickname; and his duty was to write pastoral nonsense, which they called poetry, in praise of an imaginary shepherdess. And, thus bloating their babble, they passed their "literary" life, till another generation took their place to continue their useless labours. Thus the Seicento passed into the Settecento (1675–1775) without any change or improvement in Italian literature, which really did no longer exist, as it produced no literary work of any value whatever. Muratori (1672–1750) wrote in Latin his principal work, and his *Annali d' Italia* are only a bulky and useful compilation of historical documents. Vico (1670–1744) wrote his historical works, as well as Giannone (1676–1748), Tiraboschi (1731–1794), and Pietro Verri (1728–1797), in very bad Italian, without the least pretence to literary merit or even grammatical correctness.

The Ottocento (1775–1875) began when France was preparing the great revolution, which was going to have such influence on all the various fields of European civilisation. Italy was the first to feel this revival, in its literary not less than in its political life. First and foremost among the numerous writers on social science appeared Cesare Beccaria (1738–1794) with his book *Dei delitti e delle pene.* Written in a style which recalled the golden age of the Renaissance, it was most influential in spreading the new ideas. Giuseppe Baretti (1716–1789), having resided most of his life in England, tried to bring to the knowledge of his compatriots the political and social life of his adopted country in some interesting books of travel and in a famous periodical, *La Frusta;* his only reward for his lifelong efforts being his life theatened by the poniard of an assassin; and he was obliged to fly once more from Italy to the friendly shelter of England, where he had made many and very influential friends. Greatest of these were Dr. Samuel Johnson, whose biographer, Boswell, often mentions the Italian author; and Sir Joshua Reynolds, who painted Baretti's portrait, still to be seen at Holland House. Baretti deserved well of his adopted country by helping, with Fuseli and others, in founding the Royal Academy of Arts, of which he became the first secretary. His most interesting works are *Le lettere familiari* —in which he relates his journeys through the West of England and in Portugal and Spain— and an *English-Italian Dictionary.*

Galvani (1737–1798) and Volta (1745–1826) were the pioneers of electrical science, and their names are universally known, as well as their work. Vittorio Alfieri (1749–1805), a Piedmontese nobleman, who had passed his youth and manhood in travelling and in idleness, gave

the latter part of his life to learning the Italian, the Latin, and the Greek languages, and he succeeded so well in this that he was enabled to become the author of the best tragedies of which the literature of Italy can boast. Though not possessing the genius of a Shakespeare, he contrived to make them of sufficient merit to be interesting to the Italian public. He resided a long time in England, where he even fought a duel in Windsor Park with an Irish peer, Lord Ligonier. His most interesting work is his autobiography, remarkable for its outspokenness and truth-telling, and for its description of life in the various European Courts, where he was ever a welcome visitor. His *Vita* is one of those books which no student of Italian literature should miss reading.

Giuseppe Parini (1729–1799) was a poet of literary merit, whose political satire, *Il Giorno*, lashed the shameful laziness of Italians as well as it deserved. Although Metastasio (1698–1782) belongs chronologically to the Settecento, his works claim him as one of those writers who properly belong to the following century. Poet-Laureate to the Austrian Court, he wrote an immense number of occasional verses and dramas for music, all of them remarkable for the facility of their style and for the purity of their diction.

The drama had never had a popular exponent in any period of Italian literature, until Carlo Goldoni (1707–1793) wrote his ever-popular comedies. Before his time the Italian public was satisfied with listening to bad translations of French plays, as they do even to-day. But though Goldoni's 150 plays are interesting as theatrical works for their plots and naturalness, they make no pretence whatever to any literary merit; and many of them are even written in the Venetian dialect. Unfortunately for the Italian stage, Goldoni remains to this day the only dramatist of Italy.

Under the rule of Napoleon, who had founded a kingdom of Italy, which had only an ephemeral existence of a few years, Milan, its capital, was the centre of the literary world in Italy. Here Vincenzo Monti (1754–1828) was the acknowledged leader, and here he wrote his most popular poems, whose popularity was hardly more lasting than that of the ruler under whose patronage he wrote. Ugo Foscolo (1778–1827), an officer in the republican army of France, exiled by Napoleon, found in the ever-open hospitality of England a welcome refuge, and gave himself entirely to literary work. He became famous for his song, *I Sepolcri*—a short poem on classic lines, and as mournful as its subject exacted. His critical work on Dante showed a wonderfully deep knowledge of all the intricacies and etymologies of the Italian language. He was buried at Chiswick, whence his remains were, a few years ago, carried by an Italian man-of-war to Leghorn and laid in Santa Croce in Florence.

Benedetto Sestini is well known for his sentimental poem on *Pia de' Tolomei*, the subject of which is taken from one of the most pitiful tales of love mentioned in Dante's *Divina Commedia*. Carlo Botta (1766–1837) was the author of the continuation of Guicciardini's *Storia d' Italia*, and of the *Storia della Guerra dell' Indipendenza degli Stati Uniti d' America*, both works more remarkable for their style, which recalls that of the writers of the Cinquecento, than for their historical accuracy. Antonio Cesari, in his *Bellezze della Divina Commedia*, can be classed with Botta as another "purist." A better historian is General Pietro Colletta (1775–1831), who wrote the *Storia del Reame di Napoli*, interesting alike for its beautiful style and for its historical accuracy. He was the commander of the Neapolitan troops at the time of the French occupation of Naples, when Napoleon's brother-in-law, Joachim Murat, was King of Naples, and distinguished himself for his valour and statesmanship. His descriptions of the terrible earthquake of 1783, and of the brigandage ever flourishing in the southern provinces of Italy, remind one of the writings of Tacitus. Cesare Cantù, whose long life ended only a short while ago, was the most prolific of Italian historians. Besides his *Storia Universale* of one hundred volumes, enriched by many important and rare documents, his *Storia d' Italia*, and his still more important *Storia degli Eretici in Italia*, he was the author of numerous novels, amongst them *Margherita Pusterla*, and the *Novelle Brianzuole*. Although not a classic, he is one of the best writers of this period. His popularity suffered because of his stern independence from all political parties, which have been the ruin of Italy for so many centuries.

P. Emiliani-Giudici has written a good *Storia della Letteratura Italiana*, the best on that subject; Pietro Ranalli a *Storia delle Belle Arti*, with moderate success; and Pietro Villari several works on historical subjects, of which the life of *Girolamo Savonarola* is the best.

Of modern novelists, none has had the success obtained by Alessandro Manzoni (1785–1872) with his single novel *I Promessi Sposi*, of which innumerable editions have been published in Italy, and which has had the singular honour of being translated in nearly all foreign languages. Though the story it relates is very simple, it is narrated with a charm that makes its reading universally interesting. His poem *Il Cinque Maggio*, on the death of Napoleon, is his only poetical work that deserves high praise. Massimo d' Azeglio wrote *Ettore Fieramosca*, a novel which attained almost the same popularity as that of *I Promessi Sposi*, and deserves it better. The *Ricordi* of this author form a work which all Italians should read for their own improvement, as it points out the most prominent of

the many faults of their public life, to which they owe their political and moral decadence, as well as their vain dreams of hegemony in the modern world.

Cesare Balbo, who took an important part in the political reunion of Italy under the House of Savoy, wrote a *Sommario della Storia d' Italia*, in which he accomplished the extraordinary feat of including a very accurate history of all the numerous States of the Italian Peninsula, from the fall of the Roman Empire to our days, in one single volume.

Marco Visconti, by Tommaso Grossi (1791–1853) is a readable novel, describing the troublous times of the wars between the Guelfs and Ghibellines. Guerrazzi (1805–1873), a Tuscan patriot involved in the revolution of 1848, when, after being Dictator of Tuscany, he underwent a long imprisonment to satisfy the hatred of the victorious Austrians, who had their heels on the fair lands of Italy, was one of the most entertaining and cleverest authors of this period. His novels—*L' Assedio di Firenze*, *La Battaglia di Benevento*, and *L' Asino*—are written in the purest Tuscan language, overflowing with the best idioms and the sharpest wit to be found in that cradle of the language. His *Scritti politici* are indispensable to those who desire an authentic knowledge of the facts which led to the latest struggles for the liberation of Italy from the military and political yoke of Austria.

Among the numerous other writers of more or less interesting novels are: Ferrigni, better known under his *nom de plume* of "Yorick," with his *Su e giù per Firenze*, notwithstanding its Anglophobism; G. Rovetta, a most prolific writer, and author of the *Baraonda;* Ippolito Nievo, whose *Confessioni d' un Ottuagenario* are very realistic; Giuseppe Guerzoni, a secretary and soldier of General Garibaldi, of whom he wrote the best *Vita;* Renato Fucini, whose *Veglie di Neri* and *All' aria aperta* have the literary touch and home wit of his native Tuscany; Luigi Capuana, whose novels are reckoned by the score; Emilio de Marchi, a clever writer of short stories; Ghislanzoni has written readable *Racconti* and *Novelle piacevoli;* Emilio Castelnuovo, whose novels are very popular; Felice Cavallotti, the socialist, who lost his life in a political duel; G. Giacosa, a follower of the French; and, above them all, Antonio Fogazzaro. This gifted writer, some of whose novels are well known even outside Italy, was the author of *Malombra*, *Il Santo*, *Piccolo mondo antico*, *Piccolo Mondo Moderno*, and a dozen other novels. He had more literary merit than any of his contemporaries, and was the most fortunate of them all in the remunerative success of his books. He was, in fact, the only one in Italy, with one notorious exception, who ever made money by his pen. There does not exist in Italy what we call a reading public, and the publishers cannot afford to pay for works from which no return can be expected. Thus an author there is obliged to be satisfied with any little dole the publisher may be willing to grant him, after the latter has been sufficiently lucky to sell some "editions" of the book—an edition consisting generally of only 500 copies.

The Minister of Antiquities and Fine Arts in Italy, Corrado Ricci, is the foremost specialist in that country upon these important subjects, and has written many interesting volumes on the precious treasures entrusted to his care by the Italian Government. Besides his official position, there is no other living Italian who can claim higher authority in writing about Art. His finely illustrated monographs are themselves works of art, and among the most remarkable are *La Divina Commedia*, *Le Cento Vedute di Firenze Antica*, *L' Ultimo Rifugio di Dante*, &c.

An English lady, married to an Italian nobleman, the Countess Martinengo-Cesaresco, has made for herself in her new home a great reputation as the authoress of several interesting books on Italian contemporary history. Their importance and usefulness have been acknowledged. Her life of *Cavour*, her work on the *Liberazione d' Italia*, and that on the *Patriotti italiani*, are among the best monographs extant of the troublous times of Italian unification.

The two plagues which infest the southern provinces of Italy, the Camorra and the Mafia, have been described and exposed by two powerful writers, who from different points of view came to the same conclusions about them. Renato Fucini, the witty Tuscan author abovementioned, in his *Napoli ad occhio nudo* drew such horrifying and so vivid pictures of Neapolitan life that the Italian Government suppressed the book, and confiscated and destroyed all the copies it could get hold of. Even the Library of the British Museum has not a copy of it, the most remarkable book published by an Italian on the present life of the Italians. Its realistic portrayal of the true state of things concerning the Camorra and the miserable life of the Neapolitan poor, and the terrible oppression by the wealthy chiefs of the Camorra and their all-powerful influence in the appointment of senators and even of ambassadors, are revealed with a courage that does honour to the author. Another work on the same social plague in Italy is that of an Italian judge, Giulio Gaggiano, who in his *Mala Vita Napolitana* reveals the innermost secrets of that wretched organisation of crime—a task rendered easy to him by his magisterial office. Both these writers incurred the displeasure of the Government for their unwelcome revelations; and, whilst Fucini's book was destroyed, Judge

Gaggiano was dismissed from his honourable office.

Giosue Carducci enjoyed during a long life a popularity which was only justified by his laborious literary life and by his teaching in the University of Bologna. Although he has left more than twenty volumes on a varied number of subjects, they are not of such worth as to survive him for long. His *Inno a Satana* is probably the only one of his poems which may record his name to future generations. Vincenzo Gioberti (1801–1852), who had a very chequered political life, was a prolific writer on philosophical subjects, but his greatest work was *Il Gesuita Moderno*. Benedetto Croce tries in his writings to free Italy from German "Kultur," but with rather poor success.

A little book which enjoyed in this period the greatest popularity in Italy, and was translated into all European languages, was *Le mie Prigioni*, by Silvio Pellico (1788–1854). It is a simple and unadorned narration of his sufferings in the Austrian prisons on account of his political opinions. He was one of the numerous victims of Austrian rule in Italy. The book is now almost forgotten.

The writer who in the Ottocento towered above all others, and who is the only one in that century to recall to Italian students the golden days of the Renaissance in the Cinquecento, was Giacomo Leopardi (1798–1837). A cripple, and in the last years of his short life nearly blind, his activities were simply supernatural, his knowledge of the Greek, Latin, and Italian literatures amazing, his genius of the highest order. When hardly out of his childhood he wrote Greek verses, which the learned academies of Berlin and Rome praised as newly discovered works of the golden age of Greek poetry. His *Epistolario* fills two large volumes, and, unlike any other work of a similar kind, is not only the best model of letter-writing in Italian, but also interesting throughout. His *Poesie Minori* are perfect; and, among them, his song *All' Italia* is the best poem ever written of the misfortunes and miseries of that fair land, surpassing in its excellence that on the same subject written by Petrarch. His *Scritti letterari* are models of literary criticism, whilst his *Pensieri* are full to overflowing with practical moral teaching. The *Prose artistiche* show his knowledge of the fine arts to have been as deep as it was accurate, whilst his *Dialoghi* are full of wit, and the best satires ever written on the national failings of the Italians. Whilst he secured for himself one of the highest places in the literature of Italy, he was the most industrious exponent and the sternest witness to its contemporary decadence. The morals of Leopardi are above all praise, he being one of the very few among Italian authors who have not defiled their writings with a single lewd thought or an immoral word. However, as his writings are serious and oblige the reader to think, they are not popular in the common meaning of that word with a people whose principal and only aim in life is now, as it has ever been during the last four centuries, "il dolce far niente."

Italian dictionaries are many, but the best are those of Pietro Fanfani, in one large volume, which is sufficiently complete for everyday purposes. A Tuscan, Fanfani had a thorough knowledge of the language, especially as used in his native region, and his method in arranging his work is as useful as it is praiseworthy. This is therefore the Italian dictionary which can be well recommended to the student. Another one, consisting of six large volumes, is that of Niccolò Tommaseo, a splendid and laborious work, done by the single exertions and immense industry of one man, who, only after he became blind, was assisted by another editor. It bears honourable comparison with the *Oxford English Dictionary* of Dr. Murray. But the greatest of all Italian dictionaries is the *Dizionario della Crusca*. Its last edition was begun soon after the revolution of 1848, and has been going on ever since, to-day having reached the letter N; thus it is hoped that it may be completed about 1950, if nothing interferes with the present arrangements. It will take exactly one hundred years to complete—a fair period of time, though an extraordinary one, unequalled in the literary history of any nation. Some critics suggest that such procrastination is due to the fact that the members of the Accademia della Crusca, whose duty it is to prepare that dictionary, get a personal grant from the Government of £40 a year during its publication; but no such suggestion can have any foundation in fact, the academicians being the very best Italian writers now living.

There are a large number of Italian-English and English-Italian dictionaries, but the great majority of them have too many faults to deserve any recommendation. As I am obliged to mention some—those, at least, which have a smaller number of mistakes—the following will prove useful. G. Roberts' *Italian-English and English-Italian Dictionary* has the great advantage of being bound in one volume, and is published at a moderate price. That of Millhouse and Bracciforti is in two volumes, and costs twice as much as that of Roberts, though it is not twice as good. It is a witness to the superior literary merit of Giuseppe Baretti that, although his dictionary was published more than a century and a half ago, and has been reprinted without changes several times, it is still the best English-Italian and Italian-English dictionary that we have. Naturally it does not contain any English or Italian word adopted during the last 150 years; but such words, in the Italian language at least, are not very numerous.

COURSE OF READING

Although an almost complete list of all the best Italian writers has been given, it is thought that a plan for a regular Course of Study, through which a practical knowledge of Italian Literature might be acquired, would be very useful, and save the student from ruinous loss of time.

After mastering the elementary grammatical rules already given, it would be useful to study the *First Italian Reading Book*, drawn up by myself and published by Mr. Murray. It contains extracts from nearly all the best Italian prose writers, both ancient and modern, selected with the view of making the volume interesting as well as useful to the student. Its value is enhanced by the copious grammatical and syntactical notes, which fill half the volume; by the syntactical rules governing the Italian verbs; and by a complete dictionary of all the Italian words contained in the text.

More advanced students should study R. Fornaciari's *Grammatica Italiana dell' uso moderno*, the second volume of which contains a complete Syntax, illustrated by thousands of quotations from Italian classics.

As for the poetical literature of Italy, the most recent publication and the most comprehensive is the little volume containing *Le Cento Migliori Poesie*, published by Messrs Gowans & Gray of Glasgow, of which already a fourth edition has been issued. The work contains Lyrics from authors of every period from the Trecento to the present time.

For those students who, being still more advanced, can give more time to the study of this particular subject, a more extensive course would be the following:

D'Ovidio: *Grammatica storica della lingua e dei dialetti italiani.*

Manzoni: *I Promessi Sposi.* The study of this, the best novel ever published in Italy, will enable the student to become acquainted with the most modern form of Italian prose and the style most natural and acceptable to the Italian mind of the present time. Though it is sometimes ungrammatical, according to the accepted rules of the language, it is the style which best expresses modern ideas by Italians of to-day. It is, in conclusion, the Italian language as it is spoken to-day in Italy, regardless of all rules and of all writers, whether classical or not.

As an alternative to the above novel by Manzoni, we would suggest D'Azeglio's *Ettore Fieramosca*, which has the double advantage of being shorter and of being written in a more correct style.

The next object of study should be the works of Leopardi—all his collected poems, as well as his prose works. Although he flourished early in the nineteenth century, Leopardi wrote like the Italian classics of the Cinquecento. A thorough acquaintance with his works will be the best introduction to these Italian classics. He has also the advantage of presenting to the foreign student the Italian mind at its best, and the political and moral decadence of that unfortunate country in all its nakedness.

Proceeding still further towards the Renaissance, the autobiography of Alfieri, his *Vita*, would repay the reader with a very interesting subject most skilfully dealt with by the author. In it he will find a truthful and realistic description of life in Italy and in England in the eighteenth century, as left to us by no other contemporary writer.

Le Lettere familiari of Giuseppe Baretti should at this stage form the subject to be studied. They are full of information about England and Italy in the eighteenth century, and are written in a correct and easy style. The same author gave us the first Italian-English Dictionary, which is still to-day the best of all.

The *Orlando Furioso* of Ariosto and the *Gerusalemme Liberata* of Tasso should now be read. They present no difficulties whatever; and they are the best examples of Italian poetry, only inferior to Dante's *Divina Commedia.*

Il Principe and the *Istorie fiorentine* of Machiavelli will give the student the best examples of Italian prose. Of the former work there is a recent translation by myself, published in the collection of the *World's Classics*. While concise like Tacitus, Machiavelli possesses a style perfectly clear, his logic being persuasive and convincing.

The poetry of Berni, who gave his name (*bernesco*) to the humoristic poetry of Italy, should be the object of earnest study to those who wish to know the immense wealth of charming idioms possessed by the Italian language. Although often coarse, as was natural at a time when Popes witnessed the obscene plays of a Cardinal da Bibbiena in the Vatican, Berni is always moral in the best sense of the word and witty.

Cellini's *Vita* is the most interesting and entertaining book ever written in Italian. The great artist, whose literary education had been of the most elementary kind, dictated his autobiography to his favourite apprentice, who wrote it with all the peculiarities of the Florentine pronunciation of his gifted master. In it are related innumerable anecdotes of the lives of the great artists who flourished in Italy in the Renaissance, and of the courts of Rome and of Paris, where Cellini had been a welcome guest and a worried artist. His travels through Switzerland to France, his military service in the Castle of Sant' Angelo, when Rome was besieged, taken, and sacked by the army of Charles V. under the command of the Duke of Bourbon, whom Cellini asserts that he killed with a cannon-shot, are some of the events

recorded in that wonderful book, which has had the privilege of being translated into English by Roscoe and into German by Goethe.

Boccaccio's *Vita di Dante* and the greater number of his *Novelle* are the best examples of perfect prose in Italian literature. The most wonderful thing recorded in the literary history of Italy is the fact that, both in prose and in poetry, the earliest writers were absolutely the best—not one of their successors approaching, let alone surpassing, either Dante or Boccaccio.

Of the much-overrated Petrarch, to whom Italy owed the enervated and lackadaisical literature of the subsequent centuries, the only things really worth reading are the *Trionfi* and a few *Canzoni*.

We come at last to the earliest worth recording as well as to the greatest writer in Italian—to him who may be literally qualified as the creator of the Italian language—to Dante. Without mentioning his Latin works, his greatest are *La Vita Nuova*, in which he records his love for his fair neighbour, Beatrice Portinari, and his *Divina Commedia*, the sublime Poem, which placed his name on a level with those of Homer and of Shakespeare. By the time our student has proceeded so far in his Italian study, he will be able to read the Poem without the treacherous help of a translator. As, however, he will require immense information on the history, theology, astronomy, &c., of Dante's times, he will need some indispensable notes to the poem. The most useful of these will be supplied him with the translations of Cary and of Longfellow, which are also the best. The student must be earnestly warned against making use of the many works on the immortal Poem. There are more than ten thousand such books, each one of which seems to have been written rather to gain notoriety for its writer than to illustrate the Poem.

The following volumes may fittingly complete the library of the student of the Italian language and literature :—

N. Caix: *Studi di Etimologia italiana e romanza.*

C. N. Caix: *Le origini della lingua poetica italiana.*

Cesare Cantù: *Storia della Letteratura italiana.*

Baretti: *Dizionario Italiano-Inglese e Inglese-Italiano ;* or Roberts: *Dizionario Italiano-Inglese e Inglese-Italiano.*

LIST OF THE BEST ITALIAN BOOKS

Alfieri, Vittorio: *Vita, Maria Stuarda.*
Alighieri, Dante: *Vita Nuova, Divina Commedia.*
Aretino, Pietro: *Commedie.*
Ariosto, Ludovico: *Orlando Furioso, Satire.*
Azeglio, Massimo: *Ettore Fieramosca, I miei Ricordi.*
Balbo, Cesare: *Storia d' Italia.*
Baretti, Giuseppe: *Lettere familiari.*
Beccaria, Pietro: *Dei delitti e delle pene.*
Berni, Francesco: *Poesie.*
Bibbia, La Santa: *Tradotta dal Diodati.*
Boccaccio, Giovanni: *Vita di Dante, Decamerone.*
Boiardo, Matteo: *Orlando innamorato.*
Botta, Carlo: *Storia d' Italia, Guerra d' Indipendenza.*
Bruno, Giordano: *Opere italiane.*
Buonarroti, Michelangelo: *Rime e lettere.*
Cantù, Cesare: *Gli Eretici in Italia, Margherita Pusterla.*
Carducci, Giosue: *Poesie.*
Caro, Annibale: *Eneide di Virgilio.*
Cellini, Benvenuto: *La Vita.*
Cesari, Antonio: *Bellezze di Dante.*
Chiabrera: *Poesie.*
Colletta, Pietro: *Storia del Reame di Napoli.*
Compagni, Dino: *Le Cronache.*
Croce, Benedetto: *Studi storici.*
Dall' Ongaro, Francesco: *Novelle.*
De Amicis, Eduardo: *Cuore, Gli Amici.*
Della Casa: *Il Galateo.*
Emiliani-Giudici, Pietro: *Storia della Letteratura italiana.*
Filangieri, Gaetano: *Scienza della Legislazione.*
Firenzuola, A.: *Novelle.*
Fogazzaro, Antonio: *Piccolo mondo antico, Piccolo mondo moderno.*
Foscolo, Ugo: *Poesie.*
Fucini, Renato: *Napoli ad occhio nudo.*
Gaggiano, Giulio: *Mala Vita Napolitana.*
Gioberti, Vincenzo: *Scritti letterari.*
Gioia, Melchiorre: *Il Galateo.*
Giusti, Giuseppe: *Poesie, Epistolario.*
Goldoni, Carlo: *Commedie.*
Gozzi, Gasparo: *Novelle e discorsi.*
Grazzini, A. F.: *Le Cene.*
Grossi, Tommaso: *Marco Visconti.*
Guarini, B.: *Il Pastor Fido.*
Guerrazzi, F. Domenico: *Battaglia di Benevento, Assedio di Firenze.*
Guicciardini, Francesco: *Storia d' Italia.*
Leopardi, Giacomo: *Poesie, I Pensieri.*
Lippi, Lorenzo: *Il Malmantile.*
Machiavelli, Niccolò: *Il Principe, Storie Fiorentine, Discorsi.*
Manzoni, Alessandro: *I Promessi Sposi.*
Mazzini, Giuseppe: *Scritti scelti.*
Metastasio, Pietro: *Drammi.*
Monti, Vincenzo: *Aristodemo.*
Nardi, Iacopo: *Storie fiorentine.*
Nievo, Ippolito: *Confessioni di un Ottuagenario.*
Novellino, (Il).
Pandolfini: *Del Governo della Famiglia.*
Parini, Giuseppe: *Poesie.*
Pellico, Silvio: *Le mie Prigioni.*
Petrarca, Francesco: *Il Canzoniere, I Trionfi.*
Pindemonte, Ippolito: *Odissea.*
Poliziano, Angelo: *Opere volgari.*
Polo, Marco: *Libro del Milione.*
Pulci, Luigi: *Il Morgante.*

Rosa, Salvatore: *Le Satire.*
Rosini, Giovanni: *Luisa Strozzi, La Monaca di Monza.*
Sacchetti, Francesco: *Le Novelle.*
Sarpi, Fra Paolo: *Lettere.*
Savonarola, Girolamo: *Prediche.*
Sestini, B.: *Pia de' Tolomei.*
Tasso, Torquato: *La Gerusalemme liberata, Aminta.*
Tassoni, A.: *La Secchia rapita.*
Tommaseo, Niccolò: *Il Serio nel Faceto.*
Vasari, Giovanni: *Vite dei Pittori.*
Verri, Pietro: *Storia di Milano.*
Villari, Pietro: *Girolamo Savonarola.*
Vinci, Leonardo da: *Frammenti letterari, Trattato della Pittura.*
Yorick: *Su e giù per Firenze.*
Zanella: *Poesie.*

LUIGI RICCI.

THE GERMAN LANGUAGE AND LITERATURE

HISTORY OF THE GERMAN LANGUAGE

At the present day the German language is spoken in the German Empire, in Austria proper, in many provinces of the Austro-Hungarian Monarchy, in German Switzerland, in the Grand Duchy of Luxemburg, and by the upper classes in the Baltic Provinces of Russia. It belongs to the West Germanic group of the Teutonic idiom (see article on "Philology"), and falls into two main divisions: (1) The Low German, and (2) the High German dialects. The home of the former is the low-lying, flat North, whereas the latter is spoken in the mountainous districts of Central and Southern Germany. The modern literary idiom arose on Central German territory, and is therefore High German in character. Although the terms "High" and "Low" are purely geographical in origin, the term "High German" is now popularly used to describe the standard language of the "Higher Classes," the idiom of literature as opposed to the dialects of the common people. Outside the modern German Empire, the Low German dialect of Holland has developed into a literary idiom, the Dutch language, on account of the political independence of the Netherlands.

The fundamental difference between the Low German and High German dialects was caused by the so-called second or High German Shift of Consonants which affected the sounds *p*, *t*, *k*, and changed them into other consonants or consonant combinations, according to the rules given below:

1. Initially.	2. After Consonants and when Double.	3. After Vowels.
p becomes *pf*	*p* becomes *(p)f*	*p* becomes *pf*
t ,, *z*	*t* ,, *(t)z*	*t* ,, *ss*, *sz*
k remains *k*	*k* remains *k*	*k* ,, *ch*

As the original consonants are preserved in English as well as in Low German, the latter form of speech is much more like the former than High German, and it is possible to give English examples to illustrate the sound-changes of the Second Shift of Consonants:

(1) *plant*=Pflanze; *ten*=zehn; *can*=kanne. (2) *cup*=Kopf (*head*); *help*=Hülfe; *cat*=Katze (from older *catt*); *heart*=Herz; *buck*=Bock. (3) *ship*=Schiff; *eat*=essen, *sat*=sasz; *make*=machen, &c. &c.

In the history of the High German language—for the Low German and Dutch idioms do not concern us here—three periods are usually distinguished: (1) The Old High German, extending from the time of the Second Shift (about 600) to about 1100; (2) the Middle High German period, 1100–1450; (3) the Modern High German period, 1450 to the present day.

The modern literary language is the product of the third period, which begins, for practical purposes, with Luther's activity as a translator. In England, France, and other countries, the language of literature developed out of the speech of the capital. This was not the case in Germany. The history of the German language (and literature) is characterised by the lack of an abiding centre. To this very day, the constitution of the Empire provides a number of capitals; by the side of Berlin—a very young city—we find the important towns of Dresden in Saxony, Munich in Bavaria, the Free Town of Hamburg, the Rhenish metropolis of Cologne, and many more, each proudly preserving its intellectual independence. Outside the Empire, Vienna forms a centre of literary activity, and so do the large and ancient cities of German Switzerland—Basel, Zürich, and Berne.

The literary language of the twelfth century, which had its home in Swabia, did not survive the decay of chivalry. The new common idiom was "invented"—if one may use this word here—to meet the exigencies of political life; it was created, in the first instance, in the chancelleries of the various rulers throughout the old Empire. About the year 1250, people began to write letters of State, documents, and laws in the German language, which gradually ousted Latin from its pre-eminent position. At first, every prince would naturally employ the local dialect. As, however, many documents were written for the purpose of exchange, and as letters were received from other districts which served as models, the more outstanding features of the respective dialects were slowly abandoned. It also happened that the smaller courts adopted the form used in the chancellery of some more powerful neighbour. In the fifteenth century, two principal chancelleries attract our attention: that of the Elector of Saxony, and that of the Emperor. In importance they overshadow all the rest, and are alone destined to play a part in the future development of the language. The former's basis is the High German idiom spoken in "Obersachsen," the country round Meissen; the

latter represents South German speech, particularly that of Austria and Bohemia.

These two chancelleries slowly began to approach each other; the Saxon dropped certain peculiarities of its Central German character, adopting Upper German forms instead, and vice versa. Thus a tolerably uniform language was evolved. But it required the genius of a great man to transform the newly developed result of compromise into the generally accepted medium of literary intercourse. This task was performed by Luther. The great reformer wished to produce a translation of the Bible which could be understood by the people at large. For that purpose, he had to adopt a form of speech acceptable to all the inhabitants of so large and diversified a country as Germany. He deliberately chose the language of the Saxon chancellery. He, of course, found the vocabulary too limited for his purpose, and he had to draw upon all the various dialects—chiefly on his own native one, that of "Obersachsen," of Meissen, and Eisleben.

Luther's language, as it was called, soon conquered the Protestant north of Germany; it became the language of the Church, of hymns, prayer, and sermon. It was adopted for all purposes of literary expression, although in their homes the people continued to use the Low or German idiom. There were no obstacles to a general acceptance of the language of Luther's Bible in Central Germany; that part of the country was more or less the home of the new idiom.

In the South, however, "Luther's German" met with a strong resistance, chiefly in the Catholic districts of Bavaria and Austria, and also in Calvinistic Switzerland. Here in the sixteenth century, Luther's authority in linguistic matters was far from being generally recognised. Indeed, two other literary idioms existed by the side of his: (1) The South German (Bavarian), and (2) the Swiss. By degrees, however, the Central German literary language gained recognition in Switzerland, and one may say that by the year 1700 it had been generally accepted in that country.

The Catholic districts of Bavaria held out half a century longer: they were not only unwilling to abandon their native idiom, but also objected to the introduction of a language with which the name of the hateful heretic was inseparably connected.

The German standard language is not the product of one single district or locality. After Luther's time, its vocabulary was enriched by borrowings from all dialects as well as by the introduction of many foreign words, taken both from classical and modern languages. In the Romantic period, numerous words that had been lost were revived by students of mediæval literature.

Whereas unity is now attained as far as the literary language is concerned, the local dialects have by no means perished entirely. Among the educated classes, the pronunciation still varies very considerably, and in conversation many local expressions and words are used that are never written, except in familiar letters. The pure, old, genuine dialects have naturally suffered; yet the common people in many districts still speak distinct idioms, and efforts are being made in various quarters to preserve them, and even to revive interest in them among educated people.

GERMAN GRAMMAR

General Directions.—I. This brief treatise on grammar is intended to serve as an introduction to the more thorough study of the German language. The German extracts should be carefully read through and compared with the English versions. It is very important that the learner should from the very beginning endeavour to acquire an extensive vocabulary. Every word met with should be put down in a note-book, the nouns with their respective articles, the genitive singular and nominative plural forms, the verbs in the infinitive, together with the 1st person singular of the imperfect, and the past participle. For example—*Nouns:* 'der Mensch,' *man, human being*, 'des Menschen,' *of* (*the*) *man*, 'die Menschen,' (*the*) *men*;—'der Mann,' *man, male person*, 'des Mannes, die Männer';—'die Seele' (feminine), *the soul*, 'der Seele,[1] die Seelen';—'das Wasser' (neuter), *the water*, 'des Wassers, die Wasser' (or 'Wässer'). *Verbs:* 'kommen' (strong verb), *to come*, 'ich kam,' *I came*, 'gekommen,' (*have*) *come*;—'wechseln' (weak verb), *to change*, 'ich wechselte, gewechselt.'[2]

The student is advised to obtain an exercise book and put down each rule at the head of a separate page. He should then enter all passages illustrating the rule underneath as he discovers them in his reading.

In order to find out the particulars about these and other words, they should be looked up in a dictionary. Cassel's *German Dictionary* can be recommended; Langenscheidt's *Pocket Dictionary of the English and German Languages* is an excellent little work, with the pronunciation of each word indicated in a simple phonetic notation. The following grammars will prove useful to the beginner: Wilson, *Outlines of German Grammar* (Clarendon Press); Atkins, *German Skeleton Grammar* (Blackie); those wishing to make a more thorough study of the language may be referred to Eve's *German Grammar*.

[1] In the case of feminine nouns it is not necessary to put down the genitive singular, as feminine nouns never change in the singular.

[2] The past participle of weak verbs need not be put down separately, as it can be derived from the imperfect by simply omitting the final *e* and prefixing *ge*.

II. The so-called *Gothic* or *German Characters* are used throughout the Empire for the printing of newspapers, periodicals, fiction, and poetry. The Roman letters are used for ornamental purposes, and more or less generally in scientific works. The learner of German must therefore make himself familiar with the black-letter type at an early stage. This should not be very difficult, as he will be used to seeing and reading a slightly modified variant in English ornamental printing. He need not acquire the art of using *German Script*, as the Roman letters may be used in writing German. He will, however, be obliged to learn to read the former if he wishes to correspond with Germans; for the Gothic letters are used almost universally by Germans writing in their own language.

All *Nouns* are written with initial capital letters. However strange this may appear to the foreigner, he will find it useful when beginning to learn the language, for he will be able to pick out the nouns and separate them from adjectives, verbs, &c., without much trouble.

German *Punctuation* differs from English in many respects. It should be closely studied in the texts from the beginning, for it may be of great help to the translator. The rule is that complete sentences, whether principal sentences or dependent (subordinate) clauses, or infinitive clauses of more than three words with 'zu' and 'um zu,' must be separated from each other by commas.

English and German have a common origin, but English has now lost much of its former Teutonic character and structure. Many German *Peculiarities of Syntax* and *Word Order* are, however, still represented in English by isolated instances in the language of prose. They are more frequent in English obsolete, and poetic diction. On the following pages the learner's attention is drawn to cases of this kind.

First Lesson.—Read and memorise the following poem. The verbal forms are printed in italics.

For a short treatise on German pronunciation, see p. 324.

GESANG DER GEISTER ÜBER DEN WASSERN	SONG OF THE SPIRITS OVER THE WATERS
Des Menschen Seele	The soul of man
gleicht dem Wasser:	is like the water:
vom Himmel *kommt* es,	from heaven it comes,
zum Himmel *steigt* es,	to heaven it rises,
ewig *wechselnd*.	eternally changing.
Strömt von der hohen,	If [there] flows from the high
steilen Felswand	steep rocky wall
der reine Strahl,	the pure stream, [tiful spray
dann *stäubt* er lieblich	(then) it falls down like beau-
in Wolkenwellen	in cloudy waves
zum glatten Fels,	on to the smooth rock,
und leicht *empfangen*,	and lightly received,
wallt er *verschleiernd*,	it flows down
leis *rauschend*	softly (rippling)
zur Tiefe nieder.	into the depth.
Ragen Klippen	If jutting cliffs
dem Sturz entgegen,	oppose the fall, [angry
schäumt er unmutig	it leaps down foaming and
stufenweise	step by step
zum Abgrund.	into the abyss.
Im flachen Bette	In (the) level channel
schleicht er das Wiesental hin,	it creeps along the meadowy valley,
und in dem glatten See	and in the smooth lake
weiden ihr Antlitz	all stars regard their faces
alle Gestirne.	with delight.
Wind *ist* der Welle	Wind is the wave's
lieblicher Buhler;	beautiful wooer;
Wind *mischt* von Grund aus	wind stirs up from the deep
schäumende Wogen.	the foaming waters.
Seele des Menschen,	Soul of man,
wie *gleichst* du dem Wasser!	how like to the water!
Schicksal des Menschen,	Fate of man,
wie *gleichst* du dem Wind!	how like to the wind!
(GOETHE, *geschrieben* in der Schweiz im Jahre 1779.)	(GOETHE, written in Switzerland in 1779.)

III. *Notes on Grammar, Word Order, &c.—Forms of the Definite Article.*—The German language recognises *Three Genders:*

	MASCULINE.	NEUTER.	FEMININE.	PLURAL OF ALL GENDERS.
Nom.	der	das	die	die
Gen.	des[sen]		der[en]	der[en]
Dat.	dem		der	den[en]
Acc.	den	das	die	die

The article is also used as a relative pronoun (=which, who, &c.); in the latter case, four forms take an additional -*en*, as indicated above in square brackets.

l. 1. This would be in prose: 'die Seele des Menschen'; compare l. 26.

l. 2. 'gleich-t,' a weak verb, infinitive 'gleich-en.' *t*, the ending of the 3rd person singular, is added to the stem. Compare 'komm-t,' 'steig-t,' &c.

l. 3. 'vom,' contracted form of 'von dem'; similarly, 'zum'='zu dem,' 'zur'='zu der,' &c.

l. 4. The word order deviates from English: 'es' the subject follows the verb instead of preceding it. This *Inversion* takes place in the principal sentence. (1) If anything but the subject begins the sentence. Here, as most usually happens, an adverbial phrase stands at the beginning. Compare ll. 22, 24. (2) If the principal sentence is preceded by a dependent clause. Compare l. 18. The same order, of course, prevails in questions. For a fourth case of inverted order, see note to l. 6.

l. 5. 'ewig' is an adverb; adjectives may be used as adverbs without ending. Compare 'leicht,' l. 12; 'leis(e),' l. 13. In English we find *to talk loud*, &c.—'wechsel-nd,' the usual ending is -*end*, but after an unstressed *el* or *er*, the *e* is dropped.

l. 6. The adjective 'hoch' has *h* instead of *ch* in all forms of more than one syllable, except in 'der höchste,' &c., *the highest*. Compare 'der hohe Baum,' *the high tree*.

l. 6. Here we find *Inversion* without apparent reason, for the sentence is neither a question, nor does it begin with an adverb or adverbial phrase. In the present case, inversion expresses *condition*, and we must translate *if*. . . . This construction is very frequent in German (see l. 16). In English it occurs under

certain conditions only, as in "had I not held him back . . . ," "were he not my brother . . . ," &c.

l. 7. 'Felswand,' a compound; compound nouns are written in one word in German.

l. 9. 'dann' in the beginning of the sentence causes *Inversion*.

l. 10. 'Wolkenwelle(n),' another compound. Nouns that take *-en* in the plural (*weak nouns*) almost invariably end in *-en* when used as the first part of a compound. Compare l. 22. The more usual form of the noun in l. 7 is 'Felsenwand.'

l. 12. 'empfang-en,' the past participle of a *Strong Verb*, infinitive 'empfang-en.' The past participle of strong verbs always ends in *-en*. Compare English *ridden, eaten*.

l. 14. The usual form of the adjective and adverb is 'leise.'

l. 17. A certain number of *prepositions* follow the noun—*e.g.* 'dem Flusz entlang,' *along the river*; 'den Berg hinauf,' *up the mountain*.

l. 18. An adverbial formation derived from 'die Stufe,' *the step*. Compare 'gleicherweise,' *likewise*; 'glücklicherweise,' *fortunately*.

l. 25. Most nouns beginning with *Ge-* are neuter and have a collective sense: 'der Stern,' *the star*.

l. 27. The noun is used in this sense in poetry only.

ll. 31–33. Inversion caused by the preceding 'wie.'

'ge-schrieb-en,' infinitive 'schreib-en,' a strong verb, imperfect: 'ich schrieb,' *I wrote*.

Second Lesson.—*Note.*—The symbol ß (read *s–z*) is a *sharp s*, and may be rendered by *ss*. It is found for *ss* at the end of words and before *t* ('Schlösser'=*castles*, 'das Schlosz,' *the castle*), and between vowels, if the preceding vowel is pronounced long ('die Mäße,' *the measures*—'die Masse,' *the mass, quantity*).

Wir *nahmen* freundschaftlich Abschied, und fröhlich *stieg* ich den Berg *hinauf*. Bald *empfing* mich eine Waldung himmelhoher Tannen, für die ich in jeder Hinsicht Respekt *habe*. Diesen Bäumen *ist* nämlich das Wachsen nicht so ganz leicht *gemacht worden*, und sie *haben* es sich in der Jugend sauer *werden lassen*. Der Berg *ist* hier mit vielen groszen Granitblöcken *übersat*, und die meisten Bäume *muszten* mit ihren Wurzeln diese Steine *umranken* oder *sprengen*, und mühsam den Boden *suchen*, woraus sie Nahrung *schöpfen können*. Hier und da *liegen* die Steine, gleichsam ein Tor *bildend*, übereinander, und oben darauf *stehen* die Bäume, die nackten Wurzeln über jene Steinpforte *hinziehend*, und er stam Fusze derselben den Boden *erfassend*, sodasz sie in der freien Luft zu *wachsen scheinen*. Und doch *haben* sie sich zu jener gewaltigen Höhe empor *geschwungen*, und, mit den umklammerten Steinen wie *zusammengewachsen*, *stehen* sie fester als ihre bequemen Kollegen im zahmen Forstboden des flachen Landes. So *stehen* auch im Leben jene groszen Männer, die durch das Überwinden früher Hemmungen und Hindernisse sich erst recht *gestärkt* und *befestigt haben*. Auf den Zweigen der Tannen *kletterten* Eichhörnchen und unter denselben *spazierten* die gelben Hirsche. Wenn ich solch ein liebes, edles Tier *sehe*, so *kann* ich nicht *begreifen*, wie gebildete Leute Vergnügen daran *finden*, es zu *hetzen* und zu *töten*. Solche ein Tier *war* barmherziger als die Menschen, und *säugte* den schmachtenden Schmerzenreich der heiligen Genovefa.—Heine, *Harzreise*.

We took leave (of each other) in a friendly manner, and with a light heart I ascended the mountain. I was soon received by a grove of sky-high pines, for which I in every way entertain (the most reverential) respect. For to these trees growing has not been made quite so easy, and they have, in their youth, given themselves a great deal of trouble. The mountain is here sprinkled with numerous big blocks of granite, and most of the trees had been obliged to twine their roots round these stones or to split the latter, and with trouble to seek the soil from which they might derive nourishment. Here and there the stones are lying on each other, forming as it were, a gate, and on the top the trees grow, dragging their naked roots across that stone gate, and seizing the soil only at the base (foot) of the latter, so that they seem to be growing in the (open) air. And yet they have risen to that tremendous height, and as if grown into one with the encircled stones, they stand firmer than their lazy comrades in the tame forest soil of the level country. Thus stand in life those great men who have all the firmer strengthened and established themselves by subduing the (retardations and) obstacles of their youth. Amid the branches of the pines squirrels were climbing, and beneath (them) the yellow (-brown) stags (deer) quietly walked. When(ever) I see such a dear, noble animal I cannot comprehend how educated people (can) take pleasure in chasing and killing it. Such an animal was once more merciful than men, and suckled the starving *Schmerzenreich* (rich in pain) of St. Genoveva.—Heine, *Journey through the Harz Mountains*.

IV. *Study of Word Order.*—The order of words differs in principal and subordinate sentences. *Principal* sentences are such as convey in themselves an idea without the addition of another sentence. *Subordinate* sentences or clauses are such as require another, principal, sentence on which they depend, and without which they have no meaning.

Let us take the conditions in dependent clauses first.

A. The general rule is, that in *Dependent Clauses* the finite verb, *i.e.* the changeable, inflected part of the verb, comes last. In infinitive clauses, the infinitive comes last. We find the following types of dependent clauses:

(1) The ordinary (finite) verb with or without an object.

(*a*) 'laufen,' *to run*. '(Ich sehe,) daß das Pferd läuft,' (*I see*) *that the horse runs*.

(*b*) 'sehen,' *to see*. '(Er weisz es,) weil er die Tat gesehen hat,' (*He knows it*) *because he saw* (*has seen*) *the deed*.

(2) 'sein,' *to be*, and 'werden,' *to become*, with adjectives or nouns.

(*a*) '. . . weil er ein Mensch (müde) ist,' *because he is a man* (*tired*).

(*b*) '. . . dasz mein Bruder Soldat wird,' *that my brother becomes* (*a*) *soldier*.

(3) The past participle and infinitive with an auxiliary verb:

(*a*) 'werden' with a past participle, the passive voice: '. . . weil die Türe geöffnet wird,' *because the door is* (*being*) *opened*.

(*b*) '(Wir wissen,) dasz Sie gewartet haben,' (*we know*) *that you have waited*.

(*c*) '(Wir wissen,) dasz sie fortgegangen ist,' *that she has gone away*.

(*d*) Infinitives with 'können,' 'müssen,' 'sollen,' &c.: '. . . weil ich das Buch nicht finden kann,' *because I cannot find the book*.

(4) Verbs with separable prefixes go to the end of the dependent clause, and do *not* separate from their prefixes: '(Wir sahen,) wie unser Freund den Berg hinaufstieg,' *we saw how our friend ascended the mountain.*

In the infinitive clause, the 'zu,' *to*, comes between the prefix and the verb, all three being written as one word: 'vorgehen,' *to advance.* 'Friedrich befahl seinen Generalen, gegen die Festung vorzugehen,' *Frederic commanded his generals to advance against the fortress.*

B. The normal order in *Principal Sentences* is as follows:

SUBJECT.	FINITE VERB.	ADVERBS.[1]	DIRECT OR ACC. OBJ.	COMPLEMENT
Die Perser	haben	früher auf Bergen	die Sonne	verehrt.
The Persians	*have*	*formerly on mountains*	*the sun*	*worshipped.*

The *Complement* may assume *five* different forms.

(1) The complement may be completely absent:

Napoleon	gewann	im Jahre 1805	die Schlacht bei Jena.
Napoleon	*won*	*in 1805*	*the battle of Jena.*

(2) The complement may be the *Separable Prefix* of a compound verb. In the study of texts, beginners should carefully look for a possible prefix at the end of principal sentences. This prefix should be combined with the infinitive form of the finite verb, and the *compound* verb should be looked up in the dictionary. The meaning of the compound verb often is totally different from that of the original verb. Thus in the following sentence 'vorkommen' means *to occur*, whereas 'kommen' = *to come.*

(Der) Bernstein	kommt	fast nur an einigen Stellen der Ostsee	vor.
Amber	*occurs*	*almost exclusively in a few places on the Baltic.*	

(3) The complement may be the *Past Participle* of a compound tense:

Goethe	hat	in Frankfurt	seinen 'Werther'	geschrieben.
Goethe	*has*	*at Frankfurt*	*his 'Werther'*	*written.*
'Werther'	wurde	in Frankfurt		geschrieben.
'Werther'	*was*	*in Frankfurt*		*written.*
Mein Freund	ist	gestern nach Rom		abgereist.
My friend	*has*	*yesterday for Rome*		*left.*

(4) The complement may be an *Infinitive* without 'zu' after 'sollen,' 'müssen,' 'können,' 'wollen,' &c., or with 'zu' after 'sein,' 'haben,' 'wissen,' 'befehlen,' &c.:

Hannibal	wollte	in Norditalien	die Römer	überraschen.
Hannibal	*wished*	*in Northern Italy*	*the Romans*	*to surprise.*
Scipio	befahl	darauf	dem Heere	anzugreifen.
Scipio	*commanded*	*thereupon*	*the army*	*to attack.*

[1] Note that adverbs and adverbial expressions may also follow the object: 'Die Perser haben früher die Sonne auf Bergen verehrt,' &c.

Note.—The complement may consist of two past participles, as in the *Passive Construction*; in that case 'worden' (from 'werden') goes to the end: 'Die Römer waren bei Cannae von Hannibal besiegt worden,' *the Romans had been beaten by Hannibal at Cannae.*

It may consist of past participle + infinitive; in that case the former comes last: 'Mein Freund hat mich oft ihm zu schreiben gebeten,'' *my friend has often asked me to write (to him).* In sentences of this kind, however, the infinitive may be treated as a special (infinitive) clause: 'Mein Freund hat mich oft gebeten, ihm zu schreiben.'

Note.—The verbs of mood, 'müssen,' 'wollen,' &c. (see p. 313), and the verbs 'lassen,' *to let, allow, make to*; 'sehen,' *to see*; 'hören,' *to hear*, change the past participle into the infinitive, when the past participle is connected with another dependent infinitive. Instead of 'Sie hat nicht kommen gewollt,' it is correct to say, 'Sie hat nicht kommen wollen,' *she did not wish to come.* Similarly, 'Er hat das Buch binden lassen' (instead of 'gelassen'), *he has had the book bound.* When combinations of this kind occur in dependent clauses, the rule that the auxiliary, *i.e.* the finite verb, comes last is broken. The auxiliary precedes the two infinitives: 'Wir denken, dasz er den Brief nicht hat schreiben wollen,' *we think that he did not wish to write the letter.*

(5) The complement may be an *Adjective* or *Noun* after 'sein,' 'werden,' or other verbs:

Das Wetter	war	vergangenen Sommer	sehr warm.
The weather	*was*	*last summer*	*very warm.*
Die Stadt	lag	nach der Beschieszung	wie tot.
The town	*lay (was)*	*after the bombardment*	*as dead.*

(6) There are several stereotyped phrases consisting of verbs and substantives with prepositions or adjectives, which are treated as if the substantives or adjectives were the prefixes of separable verbs (see No. 2 above). Examples: 'zu Grunde gehen,' *to perish*; 'Die Expedition ging vor zwei Jahren im Polareis(e) zu Grunde (zugrunde),' *the expedition perished in the polar ice two years ago*; 'zu Stande bringen,' *to accomplish*; 'um Rat fragen,' *to ask for advice, to consult*; 'still stehen,' *to stand still*—'Der Zug stand plötzlich auf offener Strecke still,' *the train suddenly stopped in the open*; 'fest halten,' *to hold fast, to cling to.*

C. *Inversion in Principal Sentences.*—When for some reason or other the normal order (subject—finite verb) is broken—that is to say, when subject and finite verb change places, so that the latter precedes the former—we call this process *inversion.* Its extremely frequent occurrence may cause some difficulty to beginners.

(1) Inversion is found—as in English—in the *Interrogative Sentence*: 'Haben Sie London besucht?' *have you visited London?* 'Liegen

die Bücher auf dem Tisch ?' *do the books lie on the table ?*

Note that in the German question the auxiliary 'tun,' *to do*, is *not* used.

(2) If *Anything but the Subject* begins the sentence, the subject comes *after* the finite verb. The principal cases belonging here are enumerated below.

(*a*) An *adverb or adverbial phrase* may cause inversion: 'Gestern las ich Schillers Räuber,' *yesterday I read Schiller's 'Robbers.'* 'Trotz der Sommerhitze muszten die Schnitter weiter arbeiten,' *in spite of the heat the reapers were obliged to continue working.* 'Gewaltig schlug Siegfrid auf den Ambosz,' *Siegfrid powerfully struck the anvil.*

Note.—The five conjunctions, 'allein,' *however;* 'denn,' *for;* 'sondern,' *but;* 'und,' *and;* 'oder,' *or;* 'aber,' *but;* 'nämlich,' *namely, for,* do *not* affect the order of the principal sentence: 'Denn Shakespeare war ein gröszerer Dichter als Marlowe,' *for Shakespeare was a greater poet than Marlowe.*

(*b*) Any part of the sentence placed at the beginning *for emphasis* causes inversion: 'Die angenehme Nachricht hat man ihm gestern nicht mitgeteilt,' *the happy news one did not communicate to him yesterday* (they did not tell him the happy news yesterday).

(*c*) If the principal sentence is preceded by a *Dependent Clause*, inversion takes place. In most cases, the clause is simply an elaboration of an adverbial phrase: 'Wenn der Frühling kommt, schmilzt der Schnee in den Tälern,'' *when spring comes, the snow melts in the valleys.* 'Als Elisabeth gestorben war, wurde Jakob ihr Nachfolger,' *when Elizabeth had died, James became her successor.* 'Weil diese Bäume zu viel Schatten geben, will der Besitzer sie abhauen,' *because these trees give too much shadow the owner intends to cut them down.*

(3) Inversion may express *Condition* or *Supposition*, as in the following cases: 'Wäre (*subjunctive*) Schiller nicht aus Stuttgart geflohen, so hätte er vielleicht das Schicksal Schubarts geteilt,' *if Schiller had not fled from Stuttgart he might perhaps have shared the fate of Schubart.* 'Besäsze England noch seinen früheren Waldreichtum, so wäre dies für die Nation von groszem Werte,' *if England still possessed its former wealth of words, this would be of great value to the nation.*

Note.—In the above the rules governing the relative position of subject and verb have been discussed chiefly. The position of the other parts of the sentence is less strictly regulated, and the beginner will soon learn where to place them by the careful study of texts.

V. *Notes on the Second Extract.*

l. 1. 'nehmen,' *to take;* 'ich nahm, *I took;* 'genommen,' *taken.*

l. 3. Infinitive: 'hinaufsteigen,' *to ascend;* 'ich stieg hinauf, hinaufgestiegen.'

l. 4. 'mich,' *me;* accusative of 'ich.' In a principal sentence, pronouns come immediately after the finite verb; if inversion takes place, they may either precede (as in the above case) or follow the subject.

l. 6. 'h. Tannen' is genitive plural.

l. 9. 'Das Wachsen,' *growing, growth;* any infinitive may be used as a neuter noun, which corresponds to the English formation in *-ing:* 'Das *Schreiben* dieses Briefes hat lange gedauert,' *the writing of this letter has taken* (*lasted*) *a long time.*

l. 12. 'ich lasse es mir sauer werden,' an idiom, literally, *I cause it* (something indefinite, or the thing just mentioned) *to become unpleasant to me;* 'mir,' dative of 'ich.'

l. 14. 'der Block'; plural, 'die Blöcke.'

l. 19. 'wo,' literally *where*, is here used as a relative pronoun = *which.* It is followed, not preceded, by prepositions, and if the latter begins with a vowel, an *r* is inserted: 'Die Feder, womit (mit der) Bismarck den Vertrag unterschrieb,' *the pen with which Bismarck signed the treaty.*

The same applies to the adverb and pronoun 'da,' *there:* 'Da ist der Wald; viele Bäume befinden sich darin (in ihm),' *there is the wood; many trees are in it.*

l. 20. Normal order: 'Sie können schöpfen.'

l. 28. 'der-selbe,' *the same;* 'derselben' is genitive singular feminine, and refers to 'die Steinpforte.'

l. 31. Inversion caused by 'doch,' not by 'und.'

l. 33. 'geschwungen,' past participle of 'schwingen.'

l. 34. 'umklammert,' past participle of 'umklammern,' used as an adjective.

l. 35. The infinitive to this past participle is 'zusammenwachsen.'

l. 42. 'das Überwinden,' infinitive used as a neuter noun.

l. 51. 'so' is not to be translated into English.

l. 53. A peculiar German construction which requires a lengthy explanation. The idiom is 'Vergnügen finden an etwas,' *to take pleasure in* (*something*). In English, this is usually followed by a verb in *-ing*, as, for instance, . . . *in chasing.* This construction in *-ing*, or rather in the corresponding *-end*, is unknown in German. Instead, there are two other possibilities: (1) The *an* (or whatever the preposition is) may be followed by the verbal noun, *i.e.* by the infinitive used as a neuter noun: 'Gebildete heute finden Vergnügen am (= an dem) Jagen dieser Tiere,' . . . *in chasing* (*of*) *these animals.* (2) More frequently, however, the preposition is prefixed by

'da(r)' and put in the principal sentence, the second verb being given in a separate infinitive or 'dasz' clause, as in the text. Examples: 'sich verlassen auf, *to rely upon.* 'Sie können sich darauf verlassen, dasz ich kommen werde,' *you can rely on my coming* (*that I shall come*); or, 'Sie können sich auf mein Kommen verlassen.'—'hören von,' *to hear about.* 'Wir haben nichts davon gehört, dasz er uns besuchen will,' *we have heard nothing of his intention to visit us.* The alternative construction is clumsy, but not impossible: 'Wir haben nichts von seinem uns Besuchen wollen gehört.'

l. 57. 'als' is used after the comparative =*than.*

l. 58. 'schmacht-end,' present participle to 'schmachten,' *to starve,* used as an adjective.

Note.—Make a close study of the word-order in the following two passages.

Third Lesson.—The two subjoined extracts form a complete contrast, both in style and vocabulary. The first is couched in extremely simple and homely language; the second is characteristic of Schiller's ponderous, somewhat artificial prose.

Als der Tag anbrach, noch ehe die Sonne aufgegangen war, kam schon die Frau und weckte die beiden Kinder: "Steht auf, ihr Faulenzer, wir wollen in den Wald gehen und Holz holen." Dann gab sie jedem ein Stückchen Brot und sprach: "Da habt ihr etwas für den Mittag, aber eszt's nicht vorher auf, weiter kriegt ihr nichts." Gretel nahm das Brot unter die Schürze, weil Hänsel die Steine in der Tasche hatte. Danach machten sie sich alle zusammen auf den Weg nach dem Wald. Als sie ein Weilchen gegangen waren, stand Hänsel still und guckte nach dem Haus zurück und tat das wieder und immer wieder. Der Vater sprach: "Hänsel, was guckst du da und bleibst zurück; habe acht und vergisz deine Beine nicht." "Ach Vater," sagte Hänsel, "ich sehe nach meinem weiszen Kätzchen, das sitzt oben auf dem Dach und will mir Ade sagen." Die Frau sprach: "Narr, das ist dein Kätzchen nicht, das ist die Morgensonne, die auf den Schornstein scheint." Hänsel aber hatte nicht nach dem Kätzchen gesehen, sondern immer einen von den blanken Kieselsteinen aus seiner Tasche auf den Weg geworfen.

Als sie mitten in den Wald gekommen waren, sprach der Vater: "Nun sammelt Holz, ihr Kinder, ich will ein Feuer anmachen, damit ihr nicht friert." Hänsel und Gretel trugen Reisig zusammen, einen kleinen Berg hoch. Das Reisig ward angezündet, und als die Flamme recht hoch brannte, sagte die Frau: "Nun legt euch ans Feuer, ihr Kinder, und ruht euch aus, wir gehen in den Wald und hauen Holz. Wenn wir fertig sind, kommen wir wieder und holen euch ab."—Aus *Grimms* '*Märchen.*'

At daybreak (when day began), even before the sun had risen, the woman came and roused the two children: 'Get up, (you) laggards, let us go into the forest to fetch food.' Then she gave (to) each a small piece of bread and said: 'Here is something for (your) dinner, but don't eat it (up) before; you will get nothing else (further).' Gretel carried the bread under her apron, because Hänsel had the stones in his pocket. After that they started all together for the forest. When they had walked a short while, Hänsel stopped and looked back at the house, and did this again and again. The father said: 'Hänsel, what are you looking for, and why do you lag behind? Take care, and do not forget that you have legs.' 'Oh, father,' said Hänsel, 'I am looking at my little white cat, which is sitting high upon the roof and wishes to say good-bye to me.' The woman said: 'Fool, that is not your little cat, it is the morning sun, which shines on the chimney-top.' But Hänsel had not been looking at the kitten, but (had) each time dropped one of the shining pebbles from his pocket on the road.

When they had come (right) into the middle of the forest the father said: 'Now (go and) gather wood, you children; I mean to light a fire, so that you may not be cold.' Hänsel and Gretel collected dead wood (a heap) as high as a small mountain. The dead wood was lighted, and when the flame was burning very high the woman said: 'Now lie down by the fire, (you) children, and rest; we are going into the forest to cut wood. When we have finished, we (shall) come back and fetch you.'—From *Grimm's* '*Fairy Tales.*'

VI. *Notes and Explanations.*—l. 1. 'als,' *when,* is used in connection with a single act *in the past;* 'wenn'=*when,* is used of recurring actions, to describe a habit, &c.—'z.B.' (*e.g.*), 'Wenn der Tag anbrach, kam die Frau,' *regularly at daybreak.* . . .

l. 3. The usual meaning of 'schon' is *already;* in many cases, however, it only slightly modifies the meaning of the whole sentence, and cannot be translated literally. In the present case it emphasizes the word 'noch,' *even* (l. 1).

l. 9. 'Stück-chen,' the diminutive of 'Stück,' *piece.* Diminutives are formed by adding *-chen* to the stem; all diminutives are neuter. If the vowel of the stem is *a, o, u,* or *au,* the addition of *-chen* causes 'mutation'—*i.e.* the vowel is changed into *ä, ö, ü,* or *äu.* In Southern German the diminutive suffix *-lein* is used with the same effect. Formations in *-lein,* or *-el, -le* (short for *-lein*), are often met with in poetry. 'Beispiele,' *examples:* 'der Garten,' *the garden,* 'das Gärtchen'; die Flasche,' *the bottle, flask,* 'das Fläschchen'; 'das Brot,' *the bread,* 'das Brötchen,' *the roll;* 'Hans,' short for 'Johannes,' 'Hänsel,' &c.

l. 12. 'Mittag,' *noon,* for 'Mittagessen,' *dinner.*

l. 12. 'eszt's,' contracted form of 'eszt es.'

l. 13. 'weiter' is put at the head of the sentence for emphasis; it belongs to the last word: 'nichts weiter,' *nothing further.*

l. 17. 'da-nach' (compare V). 'da' is a kind of relative which refers to the whole preceding sentence—*after this.*

ll. 18, 19. 'sie machten sich auf den Weg,' *they started.* 'sich' is the reflexive pronoun, which is used much more extensively in German than in English.

l. 21. 'sie waren gegangen,' *they had walked.* Verbs expressing motion and change of locality are conjugated with 'sein,' *to be,* and not 'haben,' *to have*—*e.g.* 'Ich bin mit der Eisenbahn gefahren,' *I* (*have*) *travelled by rail.* Other verbs belonging here are: 'laufen,' *to run;* 'fliegen,' *fly;* 'springen,' *jump;* 'fallen,' *fall.* Reflexive verbs, however, are always conjugated with 'haben': 'Wir haben uns gedreht,' *we have turned.*

l. 25. 'immer,' *ever,* cannot here be translated literally.

l. 32. 'die Katze,' *cat.*

l. 42. 'sondern' and 'aber' are both translated in English *but.* (*a*) 'sondern' is only used

after a negative in direct contradiction of what goes before: 'Er hat das Geld nicht verloren, sondern verschenkt,' *he has not lost the money but given (it) away.* (*b*) 'aber' is used in all other cases.

ll. 53, 54. '[das]einen kleinen Berg hoch [war]'; the words in square brackets may be left out.

l. 55. 'ward,' obsolete and poetic form of 'wurde.'

l. 57. 'brannte'; infinitive 'brennen,' *to burn.*

l. 60. 'sich ausruhen,' a reflexive verb = *to rest (oneself)*; 'euch' belongs to the nominative 'ihr,' *you* (2nd person plural).

l. 62. 'wenn' = *when*, said of the present or future. Compare 'als,' l. 1, and *note.*

l. 64. 'abholen,' *to fetch (away).*

Nichts scheint abenteuerlicher zu sein, als einen Seeplatz, der aufs vortrefflichste befestigt war, erbern zu wollen, ohne seinen Hafen einzuschlieszen. Wallenstein, der noch nie einen Widerstand erfahren, wollte nun auch die Natur überwinden und das Unmögliche besiegen. Stralsund, von der Seeseite frei, fuhr ungehindert fort, sich mit Lebensmitteln zu versehen und mit neuen Truppen zu verstärken; nichtsdestoweniger umzingelte es Wallenstein zu Lande und suchte durch prahlerische Drohungen den Mangel gründlicher Mittel zu ersetzen. "Ich will," sagte er, "diese Stadt wegnehmen, und wäre sie mit Ketten an den Himmel gebunden."

Der Kaiser selbst, welcher eine Unternehmung bereuen mochte, wovon er sich keinen rühmlichen Ausgang versprach, ergriff mit Begierde die scheinbare Unterwürfigkeit und einige annehmliche Erbietungen der Stralsunder, (um) seinem General den Abzug von der Stadt zu befehlen. Wallenstein verachtete diesen Befehl und fuhr fort, den Belagerten durch unablässige Stürme zuzusetzen. Da die dänische Besatzung schon stark geschmolzen, der Überrest der rastlosen Arbeit nicht gewachsen war und der König sich auszer Stand befand, eine grös̈zere Anzahl von Truppen an diese Stadt zu wagen, so warf sich Stralsund, mit Christians Genehmigung, dem König von Schweden in die Arme. Der dänische Kommandant verliess die Festung, um einem schwedischen Platz zu machen, der sie mit dem glücklichsten Erfolge verteidigte. Wallensteins Glück scheiterte vor dieser Stadt, und zum erstenmal erlebte sein Stolz die empfindliche Kränkung, nach mehreren verlornen Monaten, nach einem Verlust von 12,000 Toten, seinem Vorhaben zu entsagen. Aber die Notwendigkeit, in welche er diese Stadt gesetzt hatte, den schwedischen Schutz anzurufen, veranlaszte ein enges Bündnis zwischen Gustav Adolf und Stralsund, welches in der Folge den Eintritt der Schweden in Deutschland nicht wenig erleichterte.—SCHILLER, *Geschichte des Dreiszigjährigen Krieges.*

Nothing seems (to be) more foolhardy than to intend to take a naval fortress which was fortified in the most effective (splendid) fashion, without closing its harbour. Wallenstein, who (had) never before met with opposition, now wished to overcome nature (herself) and to conquer the impossible. Stralsund, free towards the sea, continued without interference to provide itself with food and to strengthen itself with new troops; notwithstanding (in spite of) this, Wallenstein surrounded it on land, and tried by means of boastful threats to counterbalance the lack of effective means. 'I intend,' he said, 'to take this town, even if it were bound to the sky with chains.'

The Emperor himself, who perhaps regretted an enterprise of which he did not expect the success to be creditable, with eagerness seized upon the apparent submissiveness and a few acceptable offers of the Stralsund citizens to command his general to retreat from the town. Wallenstein disregarded (despised) this order, and continued to harass the besieged by uninterrupted assaults. As the Danish army of occupation was already greatly diminished (melted), (and as) the remainder was not equal to the incessant effort, and as the king was unable to risk a larger number of troops for the sake of this town, Stralsund threw itself into the arms of the King of Sweden with the consent of Christian. The Danish commander left the fortress in order to make room for a Swedish one, who defended it with the happiest success. Wallenstein's fortune foundered before this town, and for the first time his pride experienced the painful shock, to (have to) give up his intention after several lost months, after the loss of 12,000 dead. But the necessity in which he had placed this town to invoke (the) Swedish aid, caused a close union between Gustavus Adolphus and Stralsund, which in the immediate future facilitated the entry of the Swedes into Germany not a little.—SCHILLER, *History of the Thirty Years' War.*

VII. *Notes and Explanations.*—l. 2. 'als' *than*, after a comparative.

l. 3. 'auf(da)s vortrefflichste' = *in the most effective manner;* a German idiom. Example: 'Der Bauer bewirtete seine Gäste aufs beste,' *the farmer feasted his guests in the best (possible) style.*

l. 8. Insert 'hatte' after 'erfahren.' In a dependent clause, the auxiliary 'haben' or 'sein' is sometimes omitted. But this is no longer considered good style.

l. 9. 'auch' = *also;* 'auch die Natur' = *even nature, nature herself.*

l. 12. '[das] von der Seeseite frei [war]'—'das' and 'war' are left out. The expression is an abbreviated dependent (relative) clause, which accounts for the peculiar position of the adjective 'frei,' the *complement.* (Compare IV, B (5).)

l. 18. The accusative object 'es' comes between the verb and the subject noun.

l. 29. 'Er versprach sich keinen rühmlichen Ausgang von der Unternehmung,' literally, *he did not promise himself a creditable result from the enterprise.*

l. 46. 'war' does duty for both preceding dependent clauses.

l. 47. 'auszer' = *outside;* 'auszer Stande,' literally, *outside the position.*

l. 55. 'einem schwedischen [Kommandanten]'; every adjective may be used as a noun, without the addition of 'einer,' *one.*

l. 68. 'in welche' = 'in die,' *in(to) which.* In modern German, it is more usual to say 'worin.' (Compare V. l. 19, and *note.*)

l. 71. 'lassen,' *to let, allow—cause.* Imperfect 'ich liesz,' past participle 'gelassen,' a strong verb. The compound 'veranlassen,' *to cause,* forms its imperfect and past participle by adding *t* to the stem—it is a weak verb: 'veranlaszte,' 'veranlaszt.'

l. 74. 'welches' = 'das,' *which.*

VIII. *The Verb.*—The German Verb has only two Simple Tenses, the Present and the Imperfect (or Past):

> **ich laufe,** ***I run, am running.***
> **er wählt,** ***he chooses.***
> **ich lief,** ***I ran, was running.***
> **er wählte,** ***he chose.***

There are three *Auxiliary Verbs,* by means of which the compound tenses are formed:

(1) 'haben,' *to have;* 'er hat gewählt,' *he has chosen.*

(2) '**sein**,' *to be*: 'sie ist gelaufen,' *she has run.*

(3) '**werden**' is used to form the passive voice, with the past participle, and the future, with the infinitive of any verb. '**werden**,' as an independent verb, means *to become*, and is connected with a noun or adjective:

> 'Wir werden bestraft,' *we are (being) punished.*
>
> 'Er wird kommen,' *he will come.*
>
> ['Die Stadt wird gröszer,' *the town grows larger.*]

Note.—The past subjunctive of 'werden' ('ich würde') is used to form a tense often called *Conditional.*

> 'Er würde mich besuchen . . .,' *he would visit me.* . . .

Apart from the auxiliary verbs, three main classes may be distinguished:

(1) *Weak Verbs*, which form their imperfect and past participle by adding *t* to the infinitive stem (the changes are *weak* or *small*):

> leb-en, *to live*, leb-te, ge-leb-t.

(2) *Strong Verbs*, which form their imperfect and past participle by a change of the stem vowel (the changes are *strong* or *considerable*):

> stehl-en, *to steal*, stahl, ge-stohl-en.

(3) The so-called *Verbs of Mood*, which are irregular and show the distinctive features of both the strong and weak conjugations:

> müss-en, ich musz, *I must*, musz-te, ge-musz-t.

IX. *The Auxiliary Verbs.*—Note that 'haben' is a weak verb, with the irregular change of *bt* to *tt* in the imperfect, and with a mutated vowel (*ä* for *a*) in the imperfect subjunctive; 'sein' is quite irregular, containing three different roots; 'werden' is a strong verb, with weak forms in the singular of the imperfect.

INFINITIVE: hab-en, *to have*; sein; werden.
PRESENT PARTICIPLE: hab-end, *having*; seiend; werdend.
PAST PARTICIPLE: ge-hab-t, *had*; gewesen; (ge)worden.

Note.—If the present participle of 'werden' is used for forming the passive voice, it loses the prefix *ge*: 'Er ist geschlagen worden,' *he has been beaten.*

		INDICATIVE.			SUBJUNCTIVE.		
		PRESENT.					
	ich	habe	bin	werde	habe	sei	werde
he *she* *it*	sie es	hat	ist	wird			
thou	du	hast	bist	wirst	habest	seiest	werdest
we *they* *you*[1]	wir sie Sie	haben	sind	werden	haben	seien	werden
you	ihr	habt	seid	werdet	habet	seiet	werdet
		IMPERFECT.					
	ich sie	hatte	war	wurde (ward [1])	hätte	wäre	würde
	du	hattest	warst	wurdest (wardst [2])	hättest	wärest	würdest
	wir sie	hatten	waren	wurden	hätten	wären	würden
	ihr	hattet	wart	wurdet	hättet	wäret	würdet

1 These old forms are now used in the higher style only.
2 Polite form of address.

PERFECT.

ich habe gehabt, *I have had*	ich habe gehabt, &c.
ich bin gewesen, *I have been*	ich sei gewesen, &c.
ich bin (ge)worden, *I have become*	ich sei (ge)worden, &c.

PLUPERFECT.

er hatte gehabt, *he had had*	er hätte gehabt, &c.
er war gewesen, *he had been*	er wäre gewesen, &c.
er war (ge)worden, *he had become*	er wäre (ge)worden, &c.

FUTURE.	CONDITIONAL.
I. ich werde { haben, *I shall have* / sein / werden	ich würde { haben, *I should have* / sein / werden
	ich würde { gehabt haben, *I should have been* / gewesen sein / (ge)worden sein

IMPERATIVE: habe, *have (thou)*; sei; werde
er habe, er soll haben, &c., *let him have*
laszt uns haben, &c., *let us have*
habet, *have (you)*; seit; werdet
haben Sie; seien Sie; werden Sie [1]

X. *The Weak Verb.*—The stem of a verb is obtained by removing the final *-en* of the infinitive. The various endings—the same as for 'haben'—may then be added to the stem. Examples: 'leb-en,' *to live*; 'sag-en,' *to speak, say*; 'reis-en,' *to travel*; 'druck-en,' *to print*; 'drück-en,' *to press*; 'wart-en,' *to wait*, &c. &c.

Note.—All simple derivative verbs are regular; as 'heilgen,' *to sanctify*, from 'heilig,' *holy*; 'marschieren,' *to march*, from 'Marsch,' &c.

> reis-en, *to travel*; reis-end, *travelling*; ge-reis-t, *travelled.*

PRESENT.	IMPERFECT.
ich reis-e / er reis-t	reis-t-e
du reis-(e)st	reis-t-(e)st
wir / sie reis-en	reis-t-en
ihr reis-(e)t	reis-t-et

The SUBJUNCTIVE has the same forms as the indicative, with the exception of the 3rd pers. sing. pres., which has *-e* instead of *-t*: 'er reis-e.'

PERFECT { ich bin gereist / ich habe gespielt } *I have* { *travelled* / *played*

PLUPERFECT { ich war gereist / ich hatte gespielt } *I had* { *travelled* / *played*

FUTURE { I. ich werde reisen / II. { ich werde gereist sein / ich werde gespielt haben

CONDITIONAL { I. ich würde reisen / II. { ich würde gereist sein [2] / ich würde gespielt haben

IMPERATIVE: reis-e, *travel (thou)*; er reis-e, *let him travel*; laszt uns reisen, *let us travel*; reis-en Sie, *travel.*

Note.—If the stem ends in *d* or *t*, add *et* instead of *t*: 'antworten,' *to reply*; 'er antwort-et,' 'ihr antwort-et'; and so throughout the imperfect: 'ich antwort-et-e.' The past participle is 'ge-antwort-et.'

Similarly, stems ending in *s*, *sch*, sometimes insert *e* before *s* of the ending, as 'du reisest,' instead of 'du reist.'

A small number of weak verbs change the vowel *e* of the present to *a* in the imperfect and past participle: 'brennen,' *to burn*, 'brannte, gebrannt'; 'senden,' *to send*, 'sandte, gesandt';

1 For the forms of *polite address*, the corresponding forms of the subjunctive are used.
2 The Conditional II may also be rendered by 'ich hätte gespielt,' 'ich wäre gereist.'

'wenden,' *to turn*, 'wandte, gewandt.' 'Sendete' and 'wendete' are, however, also found.

Denken, *to think*, dachte, gedacht; bringen, *to bring*, brachte, gebracht—are quite irregular.

XI. *The Strong Verb* has the same endings as the weak verb in the *Present*. In the *Imperfect*, the 1st and 3rd persons singular indicative are without any ending. Otherwise, the terminations are the same as for the weak verb.

Note, however, that in the *2nd* and *3rd persons present indicative* the vowel sometimes changes: *a* becomes *ä*; *e*, if long, becomes *ie*; *e*, if short, becomes *i*; *au* becomes *äu*; *o* becomes *ö*. Examples:

ich grabe, *I dig*; er gräbt.
ich stehle, *I steal*; er stiehlt.
ich treffe, *I hit, meet*; er trifft.
ich laufe, *I run*; er läuft.
ich stosze, *I push*; er stöszt.

The *Subjunctive Imperfect* is usually formed by changing the vowel and adding the endings of the weak subjunctive imperfect. (Compare the corresponding forms of 'haben,' 'hätte,' &c.) 'lesen,' *to read*; 'ich las'—'ich läse,' *I read*, &c.

The *Past Participle* always ends in *-en* (as the infinitive), and has the prefix *ge*.

The student should obtain a list of strong verbs and memorise the most important among them. It is impossible to tabulate all the possible vowel changes here; nor can we discuss all the irregularities of strong verbs. We must confine ourselves to noting a few typical cases.

INFINITIVE.	3rd PERS. SING.	IMPERFECT.	PAST PART.
befehlen, *command*	er befiehlt	befahl	befohlen
beiszen, *bite*	er beiszt	bisz	gebissen
biegen, *bend*	er biegt	bog	gebogen
binden, *bind*	er bindet	band	gebunden
bitten, *ask (for)*	er bittet	bat	gebeten
brechen, *break*	er bricht	brach	gebrochen
essen, *eat*	er iszt	asz	gegessen
fahren, *go, drive (in a vehicle)*	er fährt	fuhr	gefahren
fallen, *fall*	er fällt	fiel	gefallen
finden, *find*	er findet	fand	gefunden
fliegen, *fly*	er fliegt	flog	geflogen
geben, *give*	er gibt	gab	gegeben
gehen, *go*	er geht	ging	gegangen
halten, *hold*	er hält	hielt	gehalten
kommen, *come*	er kommt	kam	gekommen
lassen, *let, allow*	er läszt	liesz	gelassen
liegen,[1] *lie*	er liegt	lag	gelegen
nehmen, *take*	er nimmt	nahm	genommen
rufen, *call*	er ruft	rief	gerufen
schlagen, *beat*	er schlägt	schlug	geschlagen
schneiden, *cut*	er schneidet	schnitt	geschnitten
sehen, *see*	er sieht	sah	gesehen
sitzen,[1] *sit*	er sitzt	sasz	gesessen
tun, *do*	er tut	tat	getan
wissen, *know*	ich weisz er weisz wir wissen	wuszte	gewuszt

XII. *The Verbs of Mood*, or Modal Auxiliaries, are, unlike their English equivalents, fully conjugated; they possess an infinitive, past participle—in short, they are complete verbs. They usually do not convey a clear meaning by themselves, but give certain modifications to a *real* verb. They express the *possibility, necessity, lawfulness, willingness*, or *permission* of the real verb with which they are connected.

The verbs of mood have a very irregular conjugation. The student should carefully examine the meaning and application of their various forms in the texts. As they have a perfect conjugation, their use in German greatly differs from that of the English modal auxiliaries.

The verbs of mood usually exhibit different vowels in the singular and plural of the present. They form the imperfect and past participle by means of *t*. The present is conjugated like the imperfect of a strong verb.

INFINITIVE.	INDICATIVE. PRESENT.	SUBJUNCTIVE. PRESENT.	
(1) können, *I can, may, am able to.*	kann	könne	PAST PART. gekonnt. PERF. ich habe gekonnt. PLUPERF. ich hatte gekonnt. FUTURE. ich werde können (ich werde gekonnt haben). COND. ich würde können (ich würde gekonnt haben).
	du kannst	könnest	
	wir sie können Sie	können	
	ihr könnt	könn(e)t	
	IMPERFECT.		
	ich konnte, &c.	könnte, &c.	

Note.—(1) The plural of the indicative present and the subjunctive present have the same vowel as the infinitive.

(2) wollen; ich will; ich wollte; gewollt—*I wish to, intend to (I will)*. The vowel *o* does *not* change to *ö* in the subjunctive imperfect.

(3) sollen; ich soll; ich sollte; gesollt—*I am to, I ought (I shall)*.—*o* does not change to *ö*.

(4) müssen; ich musz; ich muszte; gemuszt—*I have to, must*.—*u* becomes *ü* in the subjunctive imperfect.

(5) mögen; ich mag; ich mochte; gemocht—*I like (to), I may*.—*o* becomes *ö*.

(6) dürfen; ich darf; ich durfte; gedurft—*I am allowed to, I may*.

Note 1.—After an infinitive, the past participle of the modal auxiliaries takes the form of the infinitive: 'Er hatte nicht schreiben sollen' (*not* 'schreiben gesollt'), *he had not been allowed to write*, or *he ought not to have written*.

The same applies to the verbs 'lassen,' *to let, allow, cause*; 'sehen,' *to see*; 'hören,' *to hear*: 'Er hat mich nicht singen hören,' *he did (has) not heard me sing*.

In a dependent clause, the auxiliary accompanying two such 'infinitives,' contrary to the usual rule, *precedes* the latter: 'Er weisz, dasz er nicht hätte zurückkommen dürfen,' *he knows that he was not allowed to return*.

XIII. *Separable and Inseparable Verbal Prefixes*.—This is one of the most difficult chapters of German grammar, as it is impossible to define the general meaning of each prefix.

There are three classes of prefixes: *Preposi-*

[1] The corresponding weak verbs are: 'legen,' *to put (down), place*; 'setzen,' *to put down, to sit down* = 'sich setzen.' Imperfect, 'legte,' 'setzte.'

tions, usually separable; *Prefixes proper*, inseparable and containing the vowel *e*, which is unstressed; and *Nouns*, usually separable. The compound verbs may be divided into five sections, according to whether the prefixes are separable or not. (Compare IV, B (2).)

A. *Verbs Singly Compounded Separable.*

absetzen, *to depose.* Ich setze ab; weil ich absetze.

emporheben, *to lift up.* Er hob empor.

wegbleiben, *to stay away.* Er ist weggeblieben.

Other prefixes belonging here are: *an-*, *auf-*, *aus-*, *bei-*, *bevor-*, *hin-*, *her-*, *ein-*, *fort-*, *mit-*, *nach-*, *nieder-*, *vor-*, *weg-*, *zurück-*, &c. &c.

Rules: Except in the infinitive and the two participles the prefix is separated from the verb and goes to the end, *in the principal sentence.*

In a dependent clause, however, verb and prefix together go to the end.

The *zu* of the infinitive is inserted between prefix and verb.

In the past participle, *ge-* is inserted between prefix and verb.

The separable prefixes have the main stress. *Illustrations:* 'Der Hund lief hinter dem Hasen her,' *the dog ran after the hare;* 'Der Jäger bemerkte, dasz der Hund hinter dem Hasen herlief,' *the sportsman noticed that the dog was running after the hare;* 'Der Jäger befahl dem Hund, hinter dem Hasen herzulaufen,' *the sportsman ordered the dog to run after the hare;* 'Der Hund ist hinter dem Hasen hergelaufen,' *the dog ran (has run) after the hare.*

B. *Verbs Singly Compounded Inseparable.*—These verbs are formed by prefixing either *be-*, *er-*, *ver-*, *ent-*, *emp-*, *zer-*, and *misz-*, *hinter-*, *wi(e)der-*. *Examples:* 'beweisen,' *to prove;* 'entehren,' *to dishonour;* 'empfangen,' *to receive;* 'erhalten,' *to receive, to preserve;* 'hintergehen,' *to deceive;* 'miszfallen,' *to displease;* 'vergehen,' *to vanish, pass away;* 'widerraten,' *to dissuade (counsel against);* 'zerstreuen,' *to disperse.*

These particles are unaccented ('erlau′ben,' *to permit*), and *never disjoined from the verb.* These verbs *do not take ge-* in the past participle, and the *zu* stands before the compounds *separately*, as before simple verbs.

Illustrations: 'Der Feind zerstörte die Stadt,' *the enemy destroyed the town;* 'Die Stadt wurde zerstört,' *the town was destroyed;* 'Die Römer beabsichtigten, Karthago zu zerstören,' *the Romans intended to destroy Carthage.*

C. *Verbs Separable and Inseparable.*—The prefixes of these verbs are prepositions, with the exception of 'wieder,' *again*—viz. 'durch,' *through;* 'über,' *over;* 'um,' *round;* 'unter,' *under;* 'voll,' *full.* These prefixes are *separable* when they retain the full meaning of the independent preposition. They are *inseparable* when they only slightly modify the meaning of the verb, or are used in a figurative sense. In the latter case they are unstressed.

Examples: 'ü′bersetzen,' *to cross a river;* 'überse′tzen,' *to translate.* 'Schlegel hat die Dramen Shakespeares ins Deutsche übersetzt,' *Schlegel has translated Shakespeare's dramas into German;* 'Der Fährmann hat heute mehr als hundert Menschen übergesetzt,' *the ferryman has carried across more than a hundred people to-day.*

D. *Verbs Doubly Compounded.*—Verbs belonging here have a compound prefix, as "hervorbringen,' *to produce;* 'anerkennen,' *to acknowledge.* If the second part of the prefix is separable, both are detached; if the second is inseparable, the first only is disjoined.

Examples: 'herunterfallen,' *to fall down.* 'Plötzlich fiel ein Stein herunter,' *suddenly a stone fell down;*—'vorbehalten,' *to reserve.* 'Er behielt sich den Entschlusz vor,' *he reserved his decision (to himself).*

E. *Verbs Compounded with Nouns.*—Of these some are separable (*a*), others inseparable (*b*).

(*a*) 'freisprechen,' *to acquit:* 'Er wurde freigesprochen'; 'gleichkommen, *to equal:* 'Nichts kommt ihm gleich'; 'stattfinden,' *to take place:* 'Das Fest findet morgen statt'; 'losreiszen,' *to tear off*, &c. &c.

(*b*) These take *ge* in the past participle like simple verbs, except those compounded with *voll-*: 'rechtfertigen,' *to justify:* 'Er hat sich gerechtfertigt'; 'handhaben,' *to handle;* 'vollziehen,' *to execute*, &c.

Fourth Lesson.

Nachdem wir einige Minuten gewartet hatten, trat Goethe zu uns herein und begrüszte uns freundlich. "Ich darf Sie geradezu in deutscher Sprache anreden," wendete er sich an Herrn Hutton (einen englischen Ingenieur-Offizier), "denn ich höre, Sie sind im Deutschen schon recht bewandert." Dieser erwiderte hierauf mit Wenigem freundlich, und Goethe bat uns darauf, Platz zu nehmen.	After we had waited a few minutes, Goethe joined us and greeted us cordially. 'I presume I may address you in German,' he said to Mr. Hutton (an English engineer officer), 'as I hear you are already well versed in our language.' The latter replied to this in a few polite words, and Goethe than asked us to be seated.
Die Persönlichkeit des Herrn H. muszte auf Goethe einen guten Eindruck machen, denn seine grosze Liebenswürdigkeit und heitere Milde zeigte sich dem Fremden gegenüber heute in ihrer wahren Schönheit. "Sie haben wohl getan," sagte er, "dasz Sie, um deutsch zu lernen, zu uns herüber gekommen sind, wo Sie nicht allein die Sprache leicht und schnell gewinnen, sondern auch die Elemente, worauf sie ruht, unsern Boden, Clima, Lebensart, Sitten, gesellschaftlichen Verkehr, Verfassung und dergleichen mit nach England hinüber nehmen."	The manners and appearance of Mr. H. must have made a good impression on Goethe, for his great kindness and mild serenity were to-day manifested towards the stranger in their real beauty. 'You did well,' said he, 'to come hither (across the sea) to learn German, for here you will easily and quickly acquire not only the language, but also the elements on which it rests, our soil, clime, mode of life, manners, social intercourse, constitution, and the like, (and) carry it away with you to England.'
"Das Interesse für die deutsche Sprache," erwi-	'The interest (taken) in the German language is now great in England,' replied Mr. H. 'and is becoming more general daily, so that there is now scarcely a young Englishman of good family who does not learn German.'
	'We Germans,' Goethe replied good-humouredly, 'have,

derte Herr H., "ist jetzt in England grosz und wird täglich allgemeiner, sodasz jetzt fast kein junger Engländer von guter Familie ist, der nicht deutsch lernte."

"Wir Deutsche," versetzte Goethe freundlich, "haben es jedoch Ihrer Nation in dieser Hinsicht um ein halbes Jahrhundert zuvorgetan. Ich beschäftige mich seit fünfzig Jahren mit der englischen Sprache und Literatur, sodasz ich Ihre Schriftsteller und das Leben und die Einrichtung Ihres Landes sehr gut kenne. Käme ich nach England hinüber, ich würde kein Fremder sein."—ECKERMANNS *Gespräche mit Goethe, Montag, den* 10. *January* 1825.

however, been half a century before your nation in this respect. For fifty years I have been busy with the English language and literature, so that I am very well acquainted with the writers and the (mode of) life and the administration of your country. If I went over to England, I should be no stranger (there).—ECKERMANN'S *Conversations with Goethe, Monday, January* 10, 1825.

XIV. *Notes and Explanations.*

l. 5. 'geradezu,' *straight off, without hesitation.*

l. 13. 'mit Wenigem,' dative of 'das Wenige,' from 'wenig,' *little* (of quantity, not size).

l. 16. 'Platz nehmen,' *to sit down.*

l. 22. 'sich zeigen,' *to show, manifest oneself.* The German reflexive verbs may often be rendered into English by the passive voice.

l. 23. 'gegenüber,' *opposite, towards, against,* is a preposition that may *follow* the noun. (Compare 'den Berg hinauf,' *up the mountain.*)

l. 33. 'wo(r),' literally *where,* used as a relative.

l. 34. 'Lebensart,' *mode of life.* 'Das Leben,' *life,* an infinitive used as a noun. Nouns of this kind, when used as the first part of a compound, take *s:* 'die Schaffenskraft,' *creative power;* 'Essenszeit,' *dinner-time,* &c. &c.

l. 37. 'dergleichen,' genitive plural of 'der-, die-, das-gleiche,' &c., *the like.*

l. 37. 'nach' = *to,* is used with reference to names of localities and countries: 'Wir werden im nächsten Jahre nach Berlin, nach Norwegen, nach den Alpen reisen, *next year we shall go to Berlin, to Norway, to the Alps.*

l. 51. 'Ihrer Nation,' dative singular; literally, *to your nation.*

l. 52. 'um' before numerals = *for, by.*

l. 53. 'sich beschäftigen mit,' *to occupy oneself with, to be busy with,* another reflexive verb.

l. 61. 'käme ich,' *if I came, were I to come.* The subjunctive is used in German to express irreality—'Goethe never went to England.'

A Prose Exercise.—The following passage is an excellent example of good, descriptive prose. It certainly has its difficulties, but the patient student will be rewarded by the exceptional fluency of diction and beauty of style.

Der Berg Athos mit dem gegenüberliegenden Küstenstrich des makedonischen Erzgebirges, möchte man glauben, sei eigentlich die Urheimat des Kastanienbaumes: nirgends, selbst in Kolchis, treibt er in solcher Fülle und Üppichkeit aus der Erde hervor: nirgends ist sein Blatt so hell und warmgrün, seine Frucht so süsz, sein Wuchs so riesenhaft, die Fortpflanzung so rasch und wucherisch wie hier. Man denke ja nicht an die Magerkeit der Baumwälder in Südeuropa, oder gar an die langweilige Symmetrie und feingebürstete Ordnung unserer Hof- und Kunstgehege. Auf Hagion-Oros ist freie Wildnis und kunstloses, von der Wurzel an heiter und breit belaubtes liebliches Dickicht in verschlungenen Pfaden, durch die Meisterhand der Natur für die Lust menschlichen Sinnes gepflanzt und aufgezogen. Wie es nur überall rankt und sproszt und in geiler Üppigkeit aus dem Boden dringt, ein kühnes unsterbliches Pflanzengeschlecht mit urweltlicher Kraft vom zarten, gestern geborenen Zweiglein bis zum strotzenden Strauch und durch alle Zeit- und Lebensskalen hinauf zum Mannesalter, zum Säcularbaum, zum antediluvianischen Kolosz.—J. P. FALLMERAYER, *Der heilige Berg Athos—Schilderung.*

One is tempted to believe that Mount Athos, with the coast-line of the Macedonian Iron Mountains lying opposite, really is the original home of the chestnut-tree: nowhere, not even in Colchos, does it burst out of the soil in such abundance and luxuriousness; nowhere is its leaf so bright and of so warm a green, its fruit so sweet, its size (growth) so gigantic, (the) propagation so quick and rank. One should by no means think of the meagreness of the tree-forests in Southern Europe, or still less of the tedious symmetry and well-brushed order of our court and artificial groves. On Hagion-Oros one finds an unbridled wilderness and untrained beautiful thickets, with pleasant and broad leaves growing (on the stems) from the root upwards, traversed by winding paths, planted and reared by the master-hand of Nature for the enjoyment of the human mind. How (the plants) everywhere stretch and sprout, and burst out of the soil in rank luxuriousness, a bold immortal race of plants with primeval force, from the tender young shoot born yesterday to the sturdy bush, and up through all scales of time and life to full age, to the secular tree, to the antediluvian colossus.—J. P. FALLMERAYER, *The Holy Mountain of Athos—Description.*

XV. *Notes and Explanations.* l. 5. 'man möchte glauben,' *one might believe*—better, *one is tempted to believe.* Here the subjunctive ('möchte,' instead of 'mochte') expresses a possibility, supposition, slight doubt.

l. 5. 'sei,' *be,* the subjunctive of 'sein.' The subjunctive is regularly used in *Indirect Speech* when the actual words of the original speaker (or thinker) are not quoted, but are merely reported.

Direct Speech: Karl V sagte: 'Ich will nicht länger regieren,' *Charles V said: 'I will rule no longer'*; Viele glauben: 'Dieser Wald ist die Heimat des Kastanienbaumes,' *many think: 'This wood is the home of the chestnut-tree.'*

Indirect Speech: Karl V (der Fünfte) sagte, er wolle nicht länger regieren.—Viele glauben, dieser Wald sei (*or* wäre) die Heimat des Kastanienbaumes.

l. 7. On account of the immediately preceding negative, 'nirgends,' 'nicht' is left out after 'selbst.' The latter = *even;* another word for *even* in the present sense is 'sogar.'

l. 10. The suffixes *-heit* and *-keit* are used to form abstract nouns from adjectives.

l. 12. 'warmgrün,' *of a warm green colour.*

l. 17. 'man denke;' the subjunctive expresses a modest wish, which, however, is here intensified by the following "ja."

l. 21. 'fein' = *nicely, well.*

l. 22. **'Hof' and 'Kunst' are both prefixes to 'Gehege,'** *park, grove.*

l. 27. Here we have a typical German construction, a past or present participle ('belaubt') used as an adjective *before the noun.* In cases of this kind the English order of words is completely inverted: 'Die hölzerne, von Cæsar im Jahre 40 über den Rhein gebaute Brücke,' *the* (1) *wooden* (2) *bridge* (7) *thrown* (6) *over the Rhine* (5) *in* 40 (4) *by Cæsar* (3).—Der herrliche, von der Königin Elisabeth gepflanzte Baum.

l. 28. 'verschlungen,' *interlaced,* past participle of 'verschlingen' (which also means *to swallow!*).

l. 31 ff. The past participles 'gepflanzt' and 'aufgezogen' go to the end of the phrase, which is an abbreviated dependent (relative) clause.

l. 32. 'es,' *it,* used impersonally for something that defies exact definition: nature, the principle of growth. The 'nur' cannot be translated literally: *Only look, how everything is sprouting. . . .*

l. 35. 'dringen, drang, gedrungen,' *to push forward, force one's way.*

l. 37. The prefix 'ur-' means *original, primeval.*

l. 38. 'vom . . . bis zu,' *from . . . to.*

XVI. *The Declension of Nouns.*

A. *The Genders.*—In English, animate beings are, according to their natural sex, either masculine or feminine; inanimate objects and ideas, with a few exceptions, neuter. This is not the case in German; several names of animate beings are of the neuter gender; inanimate objects and abstract ideas, either masculine, or feminine, or neuter—in a word, the German language still retains the old and, be it confessed, senseless institution of *Grammatical Gender.* Of most words, a knowledge of the gender is to be acquired only by experience. A few general rules will be given below.

(1) All names and appellations of males are masculine, those of females feminine, as: der Mann, *the man;* der König, *the king;* die Mutter, *the mother,* &c. All diminutives in *-chen* or *-lein* are neuter: das Männchen, *the little man, dwarf;* das Fräulein, *the young (unmarried) lady.* Das Weib, *the woman,* is neuter.

(2) There exist, besides the sexual denomination of individuals, a number of appellatives for the whole species of certain (domestic) animals, which are neuter: das Pferd, *the horse;* der Hengst, *the stallion;* die Mähre, *the mare;* das Rind, der Stier, *bull;* die Kuh, *cow.* Compare also: der Knabe, *boy;* das Kind, *child* (like—das Kalb, Füllen,' *calf, foal*); but: 'das Mädchen,' *girl,* because it is a diminutive. *Note:* der Mensch, *the human being* (in general); der Mann, *man, male person.*

(3) The termination *-in* (inflected forms *-innen*) is given to certain names of animated beings and titles to denote the feminine gender: der König, *king,* die Königin, *queen;* der Freund—die Freundin, (*male and female*) *friend;* der Herzog, *duke,* die Herzogin, *duchess;* der Schäfer—die Schäferin, *shepherd(ess)*; der Engländer, *the Englishman,* die Engländerin, *the Englishwoman* (but: der Deutsche, *the German,* die Deutsche); der Wolf, *wolf,* die Wölfin, &c. &c.

(4) Of the *Masculine Gender* are the names of winds, seasons, months, and days: der Nordwind; der Frühling, *spring;* der Sommer, Winter; der Januar, Februar, Mai, &c.; der Montag, *Monday.* 'Das Jahr,' *the year,* is neuter, and consequently 'das Frühjahr, a synonymous term for 'der Frühling,' is also neuter. 'Die Jahreszeit,' *the season* (literally, *the time of the year*), is feminine, because the last component part, 'Zeit,' *time,* is of that gender. It is a general rule that the second element of a compound noun determines the gender.

(5) Of the *Feminine Gender* are all substantives of more than one syllable ending in *-ei, -heit, -keit, -schaft, -ung:* die Bäckerei, *baker's shop;* Heuchelei, *hypocrisy;* Freiheit, *freedom, liberty;* Freundschaft, *friendship;* Hoffnung, *hope.* 'Das Geschrei,' *clamour, noise,* forms an exception.

(6) Of the *Neuter Gender* are the names of metals and names of towns and countries: das Eisen, *iron;* Blei, *lead;* Kupfer, Gold, Silber. The names of countries and towns are without the article when they stand alone. They take the neuter article, when qualified by an adjective or a following genitive: Frankreich, *France;* das südliche Frankreich, *Southern France:* das England Karls II; das neue Berlin, *new Berlin.*

Note.—Some names of countries *always* have the article: die Schweiz, *Switzerland;* die Türkei, die Normandie; das Elsasz, *Alsatia.*

All collective nouns beginning with *Ge-* are neuter: das Gebirge, *the range of mountains* (compare—der Berg, *the mountain;* das Gebiet, *the region, territory.* 'Die Geschichte,' *history, story,* is feminine.

(7) In several words the gender marks a difference of signification; the most common examples are:

der Band, *volume (book).*	das Band, *ribbon, bond.*
der Erbe, *heir.*	das Erbe, *inheritance.*
der Heide, *pagan.*	die Heide, *heath.*
die Mark, *mark (coin).*	das Mark, *marrow.*
der Schild, *shield.*	das Schild, *sign (of a house), signboard.*
der See, *lake.*	die See, *sea.*
der Tor, *fool.*	das Tor, *gate.*

B. *The Declensions.*[1]—The German language distinguishes four cases. The *Nominative* is the ordinary form of the word, and is used in the first part of the sentence, as the *active element*

[1] The declension of German nouns (and adjectives) presents considerable difficulty to the foreign student. The obstacles, however, may be overcome by application and constant practice.

on which the verb depends. The *Accusative* is used in the second part of the sentence as the *passive element*. The *Genitive* usually expresses *possession*, the *Dative* a relation :

Der Mensch (*nom.*) ist nicht immer dem Geber (*dat.*) für das Geschenk (*accus.*) dankbar, *man is not always grateful to the giver* (*dat.*) *for the gift ;* Sogar die Krone (*nom.*) des Königs (*gen.*) muszte dem Feinde (*dat.*) übergeben werden, *even the crown of the king had to be given up to the enemy ;* Im Walde sahen wir keinen Menschen, *we saw no living being in the wood.*

Note.—The genitive habitually stands after certain verbs, without expressing possession : 'Wir erinnern uns des schönen Buches (*gen.*),' *we remember the beautiful book.*

In numerous cases, the genitive is used independently in an adverbial sense : 'morgens,' *in the morning ;* 'abends, mittags,' *in the evening, at noon ;* 'eines Tages,' *one day*, &c. &c.

(*a*) *The Weak Declension* owes its name to the fact that only one change is possible, namely, the addition of *n* or *en*. No neuter nouns belong to this declension.

SINGULAR MASCULINE.		FEMININE.	PLUR. BOTH GENDERS.	
Nom.	der Bote, *messenger*	die Gabe, *gift*	die	Boten, Gaben
Gen.	des Boten	der Gabe	der	
Dat.	dem Boten	der Gabe	den	
Acc.	den Boten	die Gabe	die	

(1) Here belong all masculine nouns of more than one syllable ending in *-e*, and a few masculines that have lost *-e* in the nominative singular, as : 'Fürst,' *prince ;* 'Soldat,' *soldier ;* 'Mensch,' *human being ;* 'Herr : der Herr, des Herren,' &c.

Note that a small number of nouns in *-e* belong to another class (see below).

(2) Most feminine nouns belong here, among which may be mentioned all ending in : *-e, -heit, -keit, -ei, -schaft, -ung, -in, -ie, -ik, -ion, -tät.*

(*b*) *The Strong Declension* uses various endings in the formation of cases.

(1) The nominative plural is without ending. *Examples :* der Esel, *ass ;* der Hammer, *hammer ;* das Messer, *knife*.

SINGULAR MASCULINE.		NEUTER.	PLUR. BOTH GENDERS.
Nom.	der Esel, Hammer	das Messer	die Esel, Hämmer, Messer
Gen.	des Esels, Hammers	des Messers	der Esel, Hämmer, Messer
Dat.	dem Esel, Hammer	dem Messer	den Eseln, Hämmern, Messern
Acc.	den Esel, Hammer	das Messer	die Esel, Hämmer, Messer

The only feminine nouns belonging here are 'die Mutter,' *mother ;* 'die Tochter,' *daughter*. They do not change in the singular (no *s* in the genitive), and change the vowel in the plural : 'die Mütter, Töchter,' *mothers, daughters.*

Here belong all masculine nouns in *-el, -en, -er*, and the isolated 'der Käse,' *cheese*, 'des Käses, die Käse,' &c. Only about twenty change the vowel in the plural. The most important among the latter are : Vater, Väter, *father ;* Apfel, Äpfel, *apple ;* Bruder, *brother ;* Vogel, *bird ;* Garten, *garden ;* Ofen, *stove, oven ;* Hafen, *harbour ;* Acker, *field ;* Nagel, *nail ;* Mantel, *mantle.*

A large number of neuter nouns belong to this declension—namely, all ending in *-el, -er, -chen, -lein ;* all collectives with initial *Ge-* and ending in *-e ;* and all infinitives (in *-en*) used as nouns. The neuter nouns never modify the vowel in the plural, except 'das Kloster,' *monastery, nunnery*—'die Klöster.'

A few masculine nouns have lost *-n* in the nominative singular, but preserve it in the other cases : der Name, *name*, des Namens, dem Namen, den Namen ; die Namen, &c. So : der Funke, *spark ;* der Gedanke, *thought ;* Glaube, *belief, faith ;* Friede, *peace ;* Haufe, *heap ;* Same, *seed ;* Wille, *will ;* 'Der Fels,' *rock*, has lost both *n* and *e*, and the same applies to the neuter 'das Herz,' *heart*, which is declined as follows : Herz, Herzens, Herzen, Herz ; *plural :* Herzen.

(2) The nominative plural ends in *-e*.

(*aa*) MASCULINES.

SINGULAR.			PLURAL.
Nom.	der Tag, *day*	Flusz, *river*	die Tage, Flüsse
Gen.	des Tages	Flusses	der Tage, Flüsse
Dat.	dem Tag(*e*)	Flusse	den Tagen, Flüssen
Acc.	den Tag	Flusz	die Tage, Flüsse

The majority of masculine nouns follow this declension. Most of them change the vowel in the plural, except the following : Abend, *evening ;* Arm, *arm ;* Besuch, *visit(or)* ; Versuch, *attempt ;* Hund, *dog ;* Huf, *hoof ;* Monat, *month ;* Mond, *moon ;* Pfad, *path ;* Punkt, *point ;* Schuh, *shoe ;* Verlust, *loss*, and a few others.

(*bb*) FEMININES.

SINGULAR.	PLURAL.
die, der, der, die Faust	die, der, die Fäuste
	Dat. den Fäusten

All nouns of this class modify the vowel in the plural. Here belong a number of monosyllables, such as : die Bank, *bench, seat* (the plural of 'die Bank,' *bank*, is 'Banken') ; Frucht, *fruit* (this is the singular—'eine Frucht, *a fruit ;* the collective term *fruit* is rendered by 'das Obst') ; Hand, *hand ;* Kraft, *power, force ;* Kuh, *cow ;* Kunst, *art ;* Macht, *might, power ;* Maus, *mouse ;* Nacht, *night ;* Stadt, *town ;* Wand, *wall ;* Wurst, *sausage ;* and all feminines in *-kunft* and *-nis :* 'die Einkunft,' *revenue*, usually employed in the plural, 'Einkünfte' ; 'die Kenntnis,' *knowledge.*

(*cc*) *Neuters.*—They are declined exactly like the masculine 'Tag' above : das Fest, des Festes, dem Fest(e), das Fest, *festival. Plural :* die Feste, der Feste, den Festen, die Feste.

Here belong some nouns with initial *Ge-* that do *not* end in *-e*, as : das Geschäft, *business, shop ;* das Gesetz, *law*. Further, a considerable

number of monosyllables, as: Bein, *leg;* Heft, *exercise book;* Haar, *hair;* Heer, *army;* Jahr, *year;* Pferd, *horse;* Reich, *empire;* Recht, *right;* Schiff, *ship;* Schwein, *pig;* Spiel, *play;* Stück, *piece;* Tier, *animal;* Ziel, *aim, goal.*

(3) The nominative plural ends in *-er*. There are no feminine nouns in this class. The addition of *-er* in the plural always causes modification of the vowel, where possible: *a—ä, o—ö, u—ü, au—äu.*

	Singular.		Plural.	
	Masc.	Neut.	Masc.	Neut.
Nom.	der Wald	das Feld	die Wäld*er*	Feld*er*
Gen.	des Wald*es*	Feld*es*	der Wäld*er*	Feld*er*
Dat.	dem Wald(*e*)	Feld*e*	den Wäld*ern*	Feld*ern*
Acc.	den Wald	das Feld	die Wäld*er*	Feld*er*

Here belong masculines, as: der Mann, die Männer, *man;* Geist, *spirit, ghost;* Gott, *God;* Wurm, *worm;* Leib, *body;* Rand, *edge;* Bösewicht, *villain.*

Neuters, as: das Bad, die Bäder, *bath;* das Band, *ribbon;* Bild, *picture;* Blatt, *leaf, sheet of paper;* Brett, *board;* Buch, *book;* Dorf, *village;* Fasz, Fässer, *barrel;* Glas, *glass;* Kind, *child;* Rad, *wheel;* Tal, *valley;* Volk, *nation;* Wort, *word;* and a large number of common monosyllables. A few words with initial *Ge-* also belong here, as: Gesicht, *face;* Geschlecht, *race, generation—gender, sex.*

(*c*) *The Mixed Declension* shows strong forms in the singular, weak forms in the plural.

Singular Masculine: der Schmerz, *pain;* See, *lake;* des Schmerzes, Sees; dem Schmerz(e), See; den Schmerz, den See. *Plural:* die Schmerzen, See(e)n, &c.

So also: Bauer, *peasant;* Staat, *state;* Untertan, *subject;* Nachbar, *neighbour;* Dorn, *thorn;* Stiefel, *boot;* and a few others. Also a small number of foreign nouns: 'Doktor, Professor, Insekt.' Note the change of accent in 'Dokto'r, Dokto'ren.'

Singular Neuter: das Bett, *bed;* Auge, *eye;* des Bettes, Auges; dem Bett(e), Auge; das Bett, Auge. *Plural:* die Betten, Augen, &c.

So also: Ende, *end;* Ohr, *ear (for hearing);* Hemd, *shirt.*

Appendix: Declension of Foreign Nouns.—It is impossible to enumerate the various rules affecting the declension of foreign nouns. We must content ourselves with giving a few examples:

Singular.	Plural.	Singular.	Plural.
das Fossil	die Fossilien	der Major	die Majore
das Mineral	die Mineralien	die Familie	die Familien
das Gymnasium	die Gymnasien	der Kanal	die Kanäle
die Krisis	die Krisen	das Programm	die Programme
das Billet	die Billets	der Chara'kter	die Charakte're
der Lord	die Lords	der General	die Generale *or* Generäle)

Notes on the Declensions

(1) The dative plural always ends in *-en*, or in *-n* after *l* and *r*.

(2) Feminine nouns never change in the singular.

(3) The nominative, accusative, and genitive plural are always alike.

(4) There are no neuter nouns belonging to the weak declension, and no feminine nouns forming the plural in *-er*.

(5) Nominative and accusative are always alike, except in the case of masculine nouns following the weak declension.

(6) Masculine and neuter nouns belonging to the strong declensions may or may not take *-e* in the dative singular. Nouns ending in *-el*, *-en*, or *-er*, however, never take *-e*.

Fifth Lesson.—The English version of the following passage is more or less literal, but the student should endeavour, after careful study of the German text, to produce a really *good* translation.

Friedrich war ein sehr eigentümlicher Mensch. Mit seinem ungeheuren Kosackenbarte und groszen düsteren Augen hatte er ein treffliches Modell zu einem Bilde meines Vaters abgegeben, das den König Saul darstellte, über den der böse Geist vom Herrn kommt. Doch wohnte in ihm vielmehr ein Geist, der keine Fliege kränken, viel weniger geneigt sein konnte, den frommen Harfenspieler David zu töten, ein sehr zarter, kindlicher Sinn, den Kinder und kindliche Naturen leicht erkannten, mit denen er daher auch gern und zutraulich verkehrte. Im allgemeinen war er menschenscheu, zog sich auf sich selbst zurück und hatte sich der Einsamkeit ergeben, die je länger, je mehr seine Vertraute wurde, und deren Reize er in seinen Bildern zu verherrlichen suchte.	Friedrich was a very peculiar being. With his enormous Cossack beard and large dark eyes he had served as (formed) an excellent model for a picture of my father which represented King Saul, who is seized by the evil spirit sent by the Lord. However, there dwelt in him rather a spirit that was unable to injure a fly, and that was much less inclined to kill the pious harp-player David—a very tender, childlike mind, which children and child-like natures easily recognised, with whom he therefore liked to associate. In general he avoided human society, retired into his own self, and had devoted himself to Solitude, who as time went on became more and more his confidante, and whose charms he sought to glorify in his pictures.
Dergleichen Bilder waren früher nicht gewesen und werden schwerlich wieder kommen, denn Friedrich war ein Einundeinzigster in seiner Art, wie alle wirkliche Genies. Es ist schade, dasz man Kunstwerke nicht beschreiben kann; man kann eben nur ihren Stoff andeuten, und es war sonderbares Zeug, was Friedrich malte. Nicht paradiesische Gegenden voll Reichtum und lachender Pracht, wie Claude sie liebte, und alle diejenigen gern sehen, die nur Stoff und Machwerk ansehen. Sehr einfach, ärmlich, ernst und schwermutsvoll, glichen Friedrichs Phantasien vielmehr den Liedern jenes alten Keltensängers, deren Stoff nichts ist als Nebel, Bergeshöhe und Heide. Ein Nebelmeer, aus dem eine einsame Felsenkoppe ins Sonnenlicht anfragt, ein öder Dünenstrand im	Pictures like these had not existed before, and will hardly return, for Friedrich was the one and only one of his kind, like all real geniuses. It is a pity that one cannot describe works of art; for it is only possible to indicate their subject, and what Friedrich painted was queer stuff. Not paradisical landscapes full of wealth and smiling splendour, such as Claude loved, and all those like to see who only regard subject and execution. Very simple, bare, serious, and full of melancholy, Friedrich's fancies resembled rather the songs of that old Celtic singer whose subject consists of nothing but mist, mountain-top, and heath. A sea of mist from which a solitary rocky summit searches for the sunlight, a barren coastline with dunes in moonlight, the fragments of a 'Greenlander' in the polar ice—such and such-like were the subjects which Friedrich painted, and which he knew how to inspire a peculiar life. My special favourite among these pictures was a young, little fir-tree in a wild

Mondschein, die Trümmer eines Grönlandfahrers im Polareise—so und ähnlich waren die Gegenstände, die Friedrich malte, und denen er ein eigentümliches Leben einzuhauchen wuszte.

Mein besonderer Liebling unter diesen Bildern war ein junges Kiefernbäumchen im wirbelnden Schneewetter. Dichter Schnee lag oben darauf und fuszhoch darum herum. Darunter aber, im Schutz des Nadeldaches, war es sehr heimlich, da war der Schnee nicht hingekommen, da schliefen die Kinder des vergangenen Sommers, Heidekraut und welke Halme und ein Paar zusammengekrochene Schneckenhäuschen, im tiefsten Frieden. Das war das ganze Bild.—WILHELM V. KÜGELGEN, *Jugend-Erinnerungen eines alten Mannes.*

storm. Thick snow was lying on its top and a foot high all round. Underneath, however, in the shelter of the roof of needles, it was very snug; there the snow had not penetrated, there slept the children of last summer, heather and faded stalk and a few snails' houses that had crept together, (all) in perfect peace. This was the whole picture.—WILHELM V. KÜGELGEN, *An Old Man's Reminiscences of His Youth.*

Note.—Mako a special study of the compound nouns in tho above passage. Note the following general rules. Words used as the first part of a compound noun usually (1) take *-en* when they belong to tho weak declension: 'Harfenspieler, Kosackenbart'; (2) words belonging to tho strong declension may take *-s*: 'Bergeshöhe,' but compare 'Nebelmeer'; (3) feminine words in *-ung*, *-heit*, *keit*, take *-s*: 'Einigkeitsbestrebungen,' *efforts towards union*; 'Verhaltungsregeln,' *rules of conduct*, &c.

XVII. *Notes and Explanations.*

l. 14. 'konnte' belongs to both 'kränken' and 'geneigt sein.'

l. 20. 'denen' refers to 'Kinder und kindliche Naturen.'

l. 26. 'je . . . je,' *the . . . the*.

28. 'deren' refers to 'Einsamkeit.

31. 'dergleiches,' a genitive plural.

35. 'einundeinzig,' literally, 'one and only.'

40. 'eben' qualifies 'nur,' and cannot be translated literally.

l. 45. 'voll Reichtum,' *full of wealth*; observe the absence of any connecting word: 'Eine Flasche voll Wein,' 'Ein Korb voll Obst,' *a basketful of fruit*. The use of the genitive after 'voll,' as in 'lachender Pracht,' is now rare.

l. 48. 'gern sehen,' *to like to see*: 'Wir lesen gern deutsche Bücher,' *we like to read German books*. The comparative of the adverb 'gern' is 'lieber,' the superlative 'am liebsten.' 'Friedrich malte lieber einfache Bilder als (*than*) paradiesische Landschaften (*landscapes*),' *to like better*; 'Er malte am liebsten schwermütige Bilder,' *he liked best to paint melancholy pictures*.

l. 51. 'gleichen,' *to be like, similar*—'glich, geglichen.'

l. 54. 'Unter dem "Keltensänger" versteht der Verfasser Ossian, dessen Werke auch in Deutschland viel bewundert wurden,' *by 'Celtic bard' the author means Ossian, whose works were much read even in Germany.*

Note that in many cases the first part of a German compound is best translated into English by an adjective: 'die Naturgeschichte,' *natural history*; 'der Reichskanzler,' *imperial chancellor*.

l. 59. 'ins' = 'in das.'

l. 62. 'Grönlandfahrer,' *a vessel sailing to (and from) Greenland.*

l. 71. 'im' = 'in dem.'

l. 74. 'darum herum,' *round* (*it*—da) *about.*

l. 83. 'zusammenkriechen, kroch, gekrochen.'

l. 84. 'Häus-chen,' *little house*; pronounce *s-ch*, and not *sch*.

'v.' = 'von.' This particle before a name indicates that the bearer belongs to the nobility.

XVIII. *Pronouns.*—Pronouns are words used for nouns. Personal pronouns are words used for names of persons and things: 'ich,' *I*; 'du,' *thou*; 'Sie,' *you*, &c.

Reflexive pronouns are used for names of persons or things, when they are the objects of an action expressed by a verb, and identical with the subjects: 'Ich lehre mich (selbst),' *I teach myself*; 'Sie wundern sich,' *you wonder*, &c.

A. *Personal Pronouns.*

	FIRST PERSON.		SECOND PERSON (FAMILIAR).		SECOND PERS. (POLITE).
	SING.	PLUR.	SING.	PLUR.	SING. AND PLUR.
Nom.	ich, *I*	wir, *we*	du, *thou*	ihr, *you*	Sie, *you*
Gen.	meiner	unser	deiner	euer	Ihrer
Dat.	mir	uns	dir	euch	Ihnen
Acc.	mich	uns	dich	euch	Sie

THIRD PERSON.

	SINGULAR.			
	MASC.	NEUT.	FEM.	PLUR. OF ALL GENDERS.
Nom	er, *he*	es, *it*	sie, *she*	sie, *they*
Gen.	seiner		ihrer	ihrer
Dat.	ihm		ihr	ihnen
Acc.	ihn	es	sie	sie

The usual form of *polite address* is 'Sie,' the 3rd person plural, with a capital letter. The familiar 'du' is used in addressing children, relatives, and intimate friends. The plural 'ihr' is used in addressing more than one of such persons as would individually be addressed as 'du.' In country districts, the plural 'Ihr' is occasionally used as the form of polite address, in speaking to one or more persons.

Beginners should always bear in mind that the gender of inanimate objects varies, and that in speaking of them the corresponding pronouns must be used: 'Wissen Sie wo meine Uhr ist? Ich habe *sie* nicht gesehen,' *do you know where my watch is? I have not seen it.*

Note.—Very often 'da' is used in place of a pronoun in connection with a preposition. 'da' or 'dar' (the latter before a vowel) always *precedes* the preposition: 'Der Schlüssel: Ich habe damit (= mit ihm) die Türe geöffnet,' *the*

key : I have opened the door with it. These formations are much more extensively used than the English corresponding *thereby, therewith.* Instead of 'da,' 'wo' also may be used.

B. *The Interrogative Pronoun.*

(1) 'wer ?' *who ?* 'was ?' *what ?*

	Masc.	Fem.	Neut.	
Nom.	wer		was	was für ein (eine, ein)? *what sort of?*
Gen.		wessen		
Dat.		wem		
Acc.	wen		was	

(2) 'welcher ?' *which ? what ?* is also used as a relative pronoun, and has the endings of a strong adjective (see No. XIX). For the relative pronoun 'der,' see No. III.

C. *Possessive Pronouns* (or adjectives).—mein, *my ;* dein, *thine ;* sein, *his* (masculine and neuter) ; ihr, *her ;* unser, *our ;* euer, *your ;* ihr, *their, your* (polite).

Their inflexions are the same as those of the strong adjectives (No. XIX), with the following exceptions. The usual endings *-er* of the nom. sing. masc., and *-es* of the nom. and acc. sing. neut. are dropped : 'sein Buch,' *his book ;* 'seine Feder,' *his pen.*

The *-er* or *-es* is restored when the pronoun stands by itself : 'Ihres (*viz.* Buch) ist nicht so klein wie dieses.'

D. *The Indefinite Article.*—'ein,' *a, one,* has the same endings as the possessive pronouns, and is subject to the same exceptions. The same applies to 'kein,' *no, none ;* 'kein Mensch,' *no man ;* 'keiner ist gekommen,' *no one has come.*

E. *Reflexive Pronouns :* ich—mich, *I—myself ;* du—dich ; er, sie, es—sich ; wir—uns, ihr—euch ; sie, Sie—sich.

'Wir waschen uns,' *we wash ourselves.* The use of the reflexive pronoun is more extensive in German than in English : 'sich wundern,' *to wonder ;* 'sich irren,' *to be mistaken ;* 'sich bezahlen,' *or* 'sich bezahlt machen,' *to pay* (i.e. *to be remunerative*) ; 'sich erinnern' (+genitive), *to remember,* &c.

'Erinnern Sie sich unserer Unterhaltung ?' *do you remember our conversation ?* 'Sie irrte sich in der Nummer, *she made a mistake about the number ;* 'Wir wundern uns über nichts mehr,' *we wonder about nothing.*

The reflexive pronouns *myself,* &c., must not be confounded with the indefinite *myself,* &c., in *I myself,* which is expressed in German by 'selbst' ; 'Er hat mir selbst geschrieben,' *he wrote me himself.*

F. *Demonstrative Pronouns.*—'dieser, diese, dieses' (or 'dies'), *this* (*one*), and 'jener, jene, jenes,' *that* (*one*), are declined like a strong adjective.

'derjenige,' *the one,* and 'derselbe,' *the same,* are declined like the article and a weak adjective. *Genitive :* 'desjenigen, derjenigen,' &c.

G. *Indefinite Pronouns.*—'man,' *one,* has the genitive 'eines,' dative 'einem,' accusative 'einen,' possessive adjective 'sein.'

'jedermann,' *everybody,* has the genitive 'jedermanns'—'jemand,' *anyone ;* 'niemand,' *no one,* end in *s* in the genitive. The other cases are the same as the nominative.

Observations on Some Pronouns.—The definite article is used instead of a possessive pronoun when the sense of the sentence cannot be mistaken : 'Ich werde das Buch in die Tasche stecken,' *I shall put the book into my pocket ;* 'Er hat den Hut in der Hand,' *he has his hat in his hand.*

The reflexive or the dative of the personal pronoun is often used where the English language employs the possessive : 'Er hat sich in den Finger geschnitten,' *he has cut his finger ;* 'Der Beamte gab es ihm in die Hand,' *the official put it into his hand.*

Sixth Lesson.—The German passage printed below is an exact translation of the English original.

Unterdessen brachte dieses dämonische Drama für Schillers Ruhm die entgegengesetztesten Ergebnisse hervor. Bei der männlichen Jugend Deutschlands wurde es mit durchaus alleinstehender Begeisterung aufgenommen, obgleich es vollkommen unwahr ist, dasz es einige Männer von Rang und glänzenden Aussichten (wie eine landläufige Fabel behauptete) dazu trieb, Karl Moor nachzuahmen, indem sie Räuber wurden. Andrerseits war das Drama zu gewaltig angelegt, um nicht in jedem Falle Seine Durchlaucht den Herzog von Würtemberg beunruhigt zu haben ; denn es liesz auf einen äuszerst revolutionären Geist und auf die höchste Kühnheit des Eigenwillens schlieszen. Aber neben diesem allgemeinen Grund zum Tadel erhob sich ein besonderer in einer so entfernten Gegend, dasz diese einzige Tatsache dazu dienen mag, die Ausdehnung sowohl als auch die Stärke des hervorgebrachten Eindrucks zu bezeugen. Das hand Graubünden war von Spiegelberg, einem der Räuber, das 'Diebsathen' genannt worden. Hierauf reichten die Amtleute jenes Landes beim Herzog eine Klage ein ; und nachdem Seine Durchlaucht Schiller zu sich gerufen und streng getadelt hatte, erliesz er den Befehl, dasz dieser gefährliche junge Student sich fortan auf seine medizinischen Studien beschränken sollte.	Meantime this demoniac drama produced very opposite results to Schiller's reputation. Among the young men of Germany it was received with an enthusiasm absolutely unparalleled. though it is perfectly untrue that it excited some persons of rank and splendid expectations (as a current fable asserted) to imitate Charles Moor in becoming robbers. On the other hand, the play was of too powerful a cast not in any case to have alarmed his serenity the Duke of Würtemberg ; for it argued a most revolutionary mind, and the utmost audacity of self-will. But, besides this general ground of censure, there arose a special one in a quarter so remote that this one fact may serve to evidence the extent as well as extensity of the impression made. The territory of the Grisons had been called by Spiegelberg, one of the robbers, 'the Thief's Athens.' Upon this the magistrates of that country presented a complaint to the Duke ; and his Highness, having cited Schiller to his presence, and severely reprimanded him, issued a decree that this dangerous young student should henceforth confine himself to his medical studies.
Die nun folgende Bedrückung Schillers weist solch ausserordentliche An-	The persecution which followed exhibits such extraordinary exertions of despotism, even for that land of irresponsible power, that we must presume the Duke to have relied more upon the hold which he had upon Schiller through his affection for parents so absolutely dependent on his Highness's power than upon any laws, good or bad, which he could have pleaded as his warrant. Germany, however, thought otherwise of the new

wendungen des Despotismus auf, selbst für jenes Land unverantwortlicher Macht, dasz wir annehmen müssen, der Herzog habe sich mehr auf die Gewalt verlassen, die er durch dessen Liebe zu so von Seiner Durchlaucht Macht abhängigen Eltern hatte, als auf irgend welche Gesetze, gute oder schlechte, die er zu seiner Rechtfertigung hätte anführen können. Deutschland jedoch dachte anders über das neue Trauerspiel als der durchlauchtige Kritiker von Würtemberg: es wurde mit gewaltigem Beifall in der benachbarten Stadt Mannheim aufgeführt; und dorthin begab sich heimlich der junge Dichter aus einem höchst entschuldbaren Interesse an seinem eigenen Schauspiel. Bei seiner Rückkehr wurde er fest gesetzt. Und da Schiller jetzt von der Tyrannei des Herzogs gründlich angewidert und mit einigem Grund darüber in Besorgnis gesetzt war, entwich er schlieszlich nach Mannheim, indem er die in Stuttgart durch den Besuch eines ausländischen Fürsten verursachte Verwirrung benutzte.—SCHILLERS *Räuber*.

tragedy than the serene critic of Würtemberg: it was performed with vast applause at the neighbouring city of Mannheim; and thither, under a most excusable interest in his own play, the young poet clandestinely went. On his return he was placed under arrest. And soon afterwards, being now thoroughly disgusted, and, with some reason, alarmed by the tyranny of the Duke, Schiller finally eloped to Mannheim, availing himself of the confusion created in Stuttgart by the visit of a foreign prince.—SCHILLER'S *Robbers*.

XIX. *Notes and Explanations.*—l. 4. 'entgegengesetzt,' from 'entgegensetzen,' *to oppose*, is used as an ordinary adjective.

l. 17. 'indem sie Räuber wurden,' *in becoming robbers.* Note the method of translating the present participle in *-ing* by a dependent clause.

l. 24. The verb is: 'es läszt schlieszen auf . . .'

l. 33. 'dienen zu,' *to serve for.* Note the construction with 'dazu,' followed by an infinitive clause.

l. 39. 'einem . . .'; the apposition in the same case (dative) as the word to which it belongs ('Spiegelberg'). Compare l. 20.

l. 80. 'höchst entschuldbar,' *most excusable.* The word *most* does not indicate the superlative, but is merely used as an adverb qualifying *excusable.* We cannot therefore translate '(am) entschuldbarsten.' In cases of this kind, *most* may be translated: 'höchst' = *in the highest degree;* 'äuszerst' = *extremely;* 'durchaus' = *thoroughly,* &c. Compare l. 23.

l. 94. This peculiar German construction is explained elsewhere. See No. XV, l. 23.

XX. *The Adjective.*—Almost all the original adjectives are monosyllables, as: jung, *young;* alt, *old;* grosz, *great, large, tall;* arm, *poor;* hart, *hard;* dick, *thick;* fest, *firm.*

Some are formed by means of the prefixes *ge-* and *be-*: bequem, *convenient;* gerecht, *just;* geheim, *secret;* genau, *exact.*

Numerous adjectives are derived from other words by means of certain terminations—(1) *-ig:* fleiszig, *industrious;* günstig, *favourable;* salzig, *salt, briny;* ruhig, *quiet.* (2) *-isch:* französisch, *French;* himmlisch, *heavenly.* (3) *-lich:* wörtlich, *liberal;* kindlich, *filial.* (4) *-bar:* furchtbar, *dreadful;* dankbar, *grateful.* (5) *-sam:* biegsam, *pliable.* (6) *-haft:* meisterhaft, *masterly;* krankhaft, *diseased.* (7) *-en* and *-ern,* denoting the material of which a thing consists, as: golden, seiden, eisern, hölzern, *golden,* &c., derived from—Gold; Seide, *silk;* Eisen, *iron;* Holz, *wood.*

These are the most frequent terminations. The addition of *-ig,* *-isch,* and *-lich* often causes a change of vowel in the root syllable: 'das Land—ländlich,' *rural.*

The German language possesses numerous compound adjectives, the first component of which is either a substantive, or adjective, or numeral, or verb, as: geistreich, *talented;* dunkelblau, *dark-blue;* dreiteilig, *of three parts, triple;* liebenswürdig, *amiable.*

A. *The Declension of Adjectives.*—Adjectives, when not immediately preceding a noun, real or understood, are invariable:

Der Baum
Die Pflanze } ist grün.
Das Gras

Adjectives are declined when they are used before a substantive. In this case they may stand before the substantive either alone ('schöner Garten,' *beautiful garden*), or they are preceded by an article ('der schöne Garten'), or a pronoun ('sein schöner Garten'), or by a numeral ('ein schöner Garten').

When preceding a noun, adjectives are treated in three different ways:

(*a*) *The Strong Declension* is used when the adjective is *not* preceded by any pronoun. The endings for the various cases are the same as for 'der' and 'dieser.'

	SINGULAR.			PLURAL.
	MASC.	NEUT.	FEM.	ALL GENDERS.
Nom.	-er	-es	-e	-e
Gen.	-es		-er	-er
Dat.	-em		-er	-en
Acc.	-en	-es	-e	-e

It is now usual, however, to change the *-s* of the genitive singular into *-n* if the noun belongs to the strong declension: 'guten Muts sein' (instead of 'gutes Muts'), *to be of good cheer;* 'geraden Wegs,' *straightway;* 'heutigen Tages,' *nowadays,* &c.

(*b*) *The Weak Declension* is used after the article and all those pronouns that exhibit the endings of the strong inflexion (No. I above). The most frequent among these pronouns are: dieser, *this;* welcher, *which, what;* mancher, *many a;* jeder, *each;* jener, *that.* After these pronouns the re-occurrence of the letters *r, s, m* is avoided. In the nom. sing. masc., fem., and neut., and in the acc. sing. fem. and neut., the

adjective ends in *e*. All other cases have *en*—*i.e.* it is declined like a weak noun.

	Singular.			Plural.
	Masc.	Neut.	Fem.	all Genders.
Nom.	-e		-e	
Gen.	-en		-en	-en
Dat.	-en		-en	
Acc.	-en	-e	-e	

(c) *The so-called Mixed Declension* is used when the adjective is preceded by the indefinite article 'ein, eine, ein,' or by a possessive pronoun, 'mein, dein, sein, ihr, unser, euer, ihr, Ihr,' or by the indefinite pronoun 'kein,' *none*, which do not indicate the masculine and neuter gender in the nominative singular and in the accusative singular neuter. (Compare No. XVIII, (3).) For this reason the adjective has in these three cases the characteristic termination of the ordinary pronoun; but in the other cases of the singular, and throughout the plural, it ends in *-en*.

Singular.

Masculine.

Nom. ein (Ihr, &c.) groszer Garten, *a (her, &c.) large garden*
Gen. eines groszen Gartens
Dat. einem groszen Garten
Acc. einen groszen Garten

(Feminine. No exceptional forms. Compare II above.)

Nom. eine rote Blume, *a red flower*
Gen. einer roten Blume
Dat. einer roten Blume
Acc. eine rote Blume

Additional Remarks on the Adjectives.—(1) Adjectives are in German frequently used as nouns. They are then written with a capital initial letter, but otherwise treated as adjectives: 'der Alte,' *the old one (man)*; 'die Alte,' *the old woman*; 'der Deutsche,' *the German*; 'ein Deutscher,' *a German*; 'der Gelehrte,' *the learned one, savant*; 'ein Gelehrter.'

The general and indefinite idea of a thing is expressed by the neuter gender: 'das Schöne,' *the beautiful*; 'das Grosze,' *the great.*

(2) In poetry the *-es* of the nominative and accusative neuter is occasionally left out: 'schön Wetter' (for 'schönes'), *fine weather.*

(3) Participles, both past and present, are treated as adjectives: 'der brennende Dornbusch,' *the burning thorn-tree*; 'das vergessene Wort,' *the forgotten word.*

(4) As adjectives are used *substantively* in German, the words *one(s)*, used in English to avoid repetition of the noun, must not be translated: 'Welche Bücher haben sie mitgebracht? Die alten,' *which books did you bring (with you)? The old ones.* 'Zeigen Sie mir bitte einige gute Bilder! Dieses ist ein besonders schönes,' *please show me a few good pictures! This is a particularly fine one.*

Neuter.

Nom. ein neues Buch, *a new book*
Gen. eines neuen Buches
Dat. einem neuen Buch
Acc. ein neues Buch

Plural.

Nom. meine (Ihre, &c.) } groszen Gärten, roten Blumen, neuen
Gen. meiner } Bücher
Dat. meinen groszen Gärten, neuen Büchern
Acc. meine groszen Gärten, neue Bücher

Note.—The general rule is that if a pronoun with the strong ending precedes, the adjective takes the weak endings; if no such pronoun precedes, or one without the strong ending, the adjective takes the strong ending. The latter is also the case when an indeclinable pronoun or numeral, or similar word, precedes. Such are: etwas, *some*; viel, *much*; nichts, *nothing*; genug, *enough*; allerlei, *all sorts of*; einerlei, *of one kind*; zweierlei, *of two kinds*, &c.; dergleichen, *such like*; solch, *such* ('solch' is also an adjective); zwei, *two*, drei, *three*, &c. *Examples*: 'mit etwas weiszem Papier,' *with some white paper*; 'allerlei Blumen,' *all sorts of flowers*; 'solch schreckliche Töne,' *such dreadful sounds.*

(5) The following adjectives are never used *before* a noun: abhold, *averse*; bereit, *ready* ('fertig,' *ready*, is used in all positions); gar, *done, ready* (said of food); gang und gebe, *current*; and a few others.

(6) The words used to denote the inhabitants of towns are formed by adding *-er* to the name of the town; those ending in *-en* sometimes lose this syllable: 'Bremen,' 'ein Bremer,' *a B. man*; 'eine Bremerin,' *a B. woman*; but 'Wilhelmshaven-er,' 'Dresden-er,' &c. These appellations are used again as *indeclinable* adjectives. *Examples*: 'die Londoner Börse' (*not* 'London B.'), *the London Exchange*; 'im Hamburger Hafen,' *in (the) H. harbour*; 'Frankfurter Zeitung,' *F. Gazette*; 'Münchener Bier,' *M. beer.*

These adjectives formerly ended in *-isch*. (Compare 'Die Kölnische Zeitung,' *the Cologne Gazette*, and 'der Kölner Dom,' *C. Cathedral.*)

The Comparison of Adjectives.—The general rule is that for the comparative *-er* is added, and *-est* for the superlative. Most monosyllabic adjectives modify the vowel when *-er* or *-est* are added: 'kalt,' *cold*; 'kälter,' *colder*; 'kältest,' *coldest.*

Note.—*au* never modifies in comparison: 'rauh,' *rough*; 'rauher, rauherst.' 'äuszer, äuszerst,' *extreme(st)*, from 'auszer,' is the only exception.

The following are among the commonest monosyllables which do *not* change the vowel in comparison: blasz, *pale*; bunt, *variegated*; falsch, *false, wrong*; flach, *flat*; froh, *joyful*; roh, *raw*; stolz, *proud*; voll, *full.*

Notes.—(1) Adjectives ending in the unaccented syllables *-el*, *-en*, *-er*, generally lose the *-e* in the comparative: 'edel,' *noble*, 'edler,' as: 'Eine edlere Frucht,' 'ein edlerer Mensch.'

(2) The superlative of 'grosz' is contracted into 'gröszt.'

(3) The *e* of the superlative ending is usually dropped, except after the 'hissing sounds' and *t, s, sz, z, sch*: 'lang,' *long*, 'länger, längst'; 'heisz,' *hot*, 'heiszer, heiszest.'

(4) Comparatives and superlatives are declined like other adjectives.

(5) The superlative, when not followed by a noun—*i.e.* when no direct comparison is implied—has a fixed (adverbial) form with *an*: 'Im Sommer ist das Wetter am (=an dem) schönsten,' *in summer the weather is finest*.

(6) The combination with *am* is the usual form of the comparative of an adverb: 'Dieses Pferd läuft am schnellsten,' *this horse runs fastest*.

(7) Note that the form with *am* usually corresponds to the English superlative without an article.

(8) *Irregular Comparisons:*

gut, *good*	besser	best, am besten
viel, *much*	mehr	meist, am meisten
hoch, *high*	höher	höchst, am höchsten
nahe, *near*	näher	nächst, am nächsten
wenig, *little*	weniger (*or* minder)	wenigst (*or* mindest)

Numerals.—A. *The Cardinal Numbers:*

0	null	13	dreizehn	50	fünfzig
1	ein	14	vierzehn	60	sechzig
2	zwei	15	fünfzehn	70	siebzig
3	drei	16	sechzehn	80	achtzig
4	vier	17	siebzehn	90	neunzig
5	fünf	18	achtzehn	100	hundert
6	sechs	19	neunzehn	101	hundert ein(s)
7	sieben	20	zwanzig	147	hundert sieben und vierzig
8	acht	21	einundzwanzig		
9	neun	22	zweiundzwanzig	200	zweihundert
10	zehn	30	dreiszig	1000	tausend
11	elf	35	fünfunddreiszig	2000	zweitausend
12	zwölf	40	vierzig	*a million*,	eine Million

Note.—Units always precede tens, and are joined by 'und' (as in *one-and-twenty*). *One*, when standing alone, is 'eins.'

B. *Ordinal Numbers.*—1*st*, der erste; 2*nd*, der zweite; 3*rd*, der dritte. From 4*th* to 19*th* inclusive add *-te* to the cardinal; from 20*th* onwards, add *-ste*: der fünfte, der sieb(en)te, der neunundzwanzigste.

The ordinals are declined like ordinary adjectives.

C. *Various Numerals.*—(1) *Adjectives* (a) *of a kind* add *-erlei* to the cardinal or adjective: dreierlei, *of three kinds*; vielerlei, *of many kinds*. (b) *-fold*, add *-fach* to the cardinal or adjective: fünffach, *fivefold*; vielfach, *manifold*.

(2) *Adverbs.*—*Once*, &c., add *-mal*: einmal, *once*; zehnmal, *ten times*; vielmal, *many times* (or 'vielmals'). Sometimes the independent noun 'das Mal' is used: 'zu drei Malen,' *at three times*; 'zu zehn verschiedenen Malen,' *at ten different times*.

(3) *Fractions.*—Add *-tel* to the stem of the ordinal: das Drittel, Viertel, Zehntel, Zwanzigstel, Neunundneunzigstel.

(4) *Half* (adjective) = halb: 'ein halbes Pfund,' *half a pound*; (noun) 'die Hälfte.' (*Note.*—'das halbe England,' but 'halb England'; 'halb fünf,' *half-past four*.)

(5) *The two* = die beiden; *both* = beide. (But note that *both . . . and* = sowohl . . . als auch.)

The whole = das Ganze; *whole* = ganz; 'der ganze Abend,' *the whole evening*, but 'ganz Deutschland,' *all Germany*.

One and a half = anderthalb; as, *e.g.*: 'anderthalb Mark,' *one mark and a half*.

Seventh Lesson.—Make a careful study of the German text and Carlyle's "Modal Translation."

Noch immer dient mir das Andenken jener Zeit zur glücklichen Unterhaltung, wenn ich unsere Berge und Täler zu durchwandern genötigt bin. Noch weisz ich mir den kleinsten Umstand zurückzurufen, womit ich euch jedoch, wie billig, verschone. Wochen gingen vorüber; Maria hatte sich erholt, ich konnte sie öfter sehen, mein Umgang mit ihr war eine Folge von Diensten und Aufmerksamkeiten. Ihre Familienverhältnisse erlaubten ihr einen Wohnort nach Belieben. Erst verweilte sie bei Frau Elisabeth; dann besuchte sie uns, meiner Mutter und mir für so vielen und freundlichen Beistand zu danken. Sie gefiel sich bei uns, und ich schmeichelte mir, es geschehe zum Teil um meinetwillen. Was ich jedoch so gern gesagt hätte und nicht zu sagen wagte, kam auf eine sonderbare und liebliche Weise zur Sprache, als ich sie in die Kapelle führte, die ich schon damals zu einem wohnbaren Saal umgeschaffen hatte. Ich zeigte und erklärte ihr die Bilder, eins nach dem andern und entwickelte dabei die Pflichten eines Pflegevaters auf eine so lebendige herzliche Weise, dasz ihr die Tränen in die Augen traten und ich mit meiner Bilderdeutung nicht zu Ende kommen konnte. Ich glaubte ihrer Neigung gewisz zu sein, ob ich gleich nicht stolz genug war, das Andenken ihres Mannes so schnell auslöschen zu wollen. Das Gesetz verpflichtet die Witwen zu einem Trauerjahre, und gewisz ist eine solche Epoche, die den Wechsel aller irdischen Dinge in sich begreift, einem fühlenden Herzen nötig, um die schmerzlichen Eindrücke eines groszen Verlustes zu mildern. Man sieht die Blumen welken und die Blätter fallen, aber man sieht auch Früchte reifen und neue Knospen keimen. Das Leben gehört den Lebendigen an, und wer lebt, musz auf Wechsel gefaszt sein.—GOETHE, *Wilhelm Meisters Wanderjahre.*

To this hour, when I chance to be wandering over our mountains and forests, the remembrance of that time forms my happiest entertainment. I can still recall the slightest particulars, which, however, as is fit, I spare you at present. Weeks passed on; Mary was recovered, I could see her oftener, my intercourse with her was a train of services and attentions. Her family circumstances allowed her to choose a residence according to her pleasure. She first stayed with Frau Elizabeth; then she paid us a visit, to thank my mother and me for so many and such friendly helps. She liked to live with us; and I flattered myself that it was partly on my account. What I wished to tell her, however, and durst not utter, came to words in a singular and pretty wise, when I took her into the Chapel, which I had then fitted up as a habitable apartment. I showed her the pictures, and explained them to her one after the other; and so doing, unfolded the duties of a foster-father in so vivid and cordial a manner, that the tears came into her eyes, and I could not get to the end of my picture exhibition. I thought myself certain of her affection, though I was not proud enough to wish so soon to efface the memory of her husband. The law imposes on widows a year of mourning; and in truth, such an epoch, which includes in it the change of all earthly things, is necessary for a feeling heart, to alleviate the painful impressions of a great loss. We see the flowers fade and the leaves fall; but we likewise see fruits ripen, and new buds shoot forth. Life belongs to the living; and he who lives, must be prepared for vicissitudes.—*Carlyle's translation of 'Wilhelm Meisters Wanderjahre.'*

XXI. *Notes and Explanations.*—l. 3. 'dienen zu' (with dative), *to serve for.*

l. 10. 'billig' = *just* (and also = *cheap*).

l. 27. 'es geschehe'—the conjunctive is used to express a doubt.

l. 28. 'um meinetwillen, seinetwillen,' &c., *for my, his sake.*

l. 30. = 'gesagt haben würde,' *would have said.*

l. 37. 'umschaffen,' *to transform.*

l. 43. Note that 'lebendig' has the accent on the second syllable, contrary to rule.

l. 44. 'ihr,' *to her.* Translate: *into her eyes.*

l. 49. 'gewisz sein eines Dinges (*genitive*),' *to be certain of. . . .*

l. 49. 'ob ich gleich . . . , *although I . . .* In present-day German one says 'obgleich ich.'

l. 68. 'angehören,' *to belong to* (with dative), poetic for the simple 'gehören.'

l. 69. 'wer,' *he who.*

XXII. *Prepositions.*—The prepositions require particular attention, not only on account of the various significations of some of them, but also on account of the *different cases which they govern.*

A. *Governing an Accusative only:*

bis, *up to, until.*
durch, *through*—*by* (instrumental, after the passive voice).
für, *for, on behalf of.*
gegen, *towards, against.*
ohne, *without.*
um, *at, (a)round.*
ausgenommen, auszer, *except.*

Examples.—'Ich bin ohne meinen Hut ausgegangen,' *I went out without my hat.* 'Werden Sie das Buch für mich mitbringen?' *shall you bring the book for me (with you)?*

B. *Governing a Dative only:*

aus, *out of.*
bei, *near, at* (also describes attendant circumstances).
gegenüber, *opposite.*
mit, *with.*
nach, *to* (a place), *after, according to.*
seit, *since.*
von, *of, by* (an agent), *from.*
zu, *to* (a person), *at.*

Examples.—'Er hat sich beim Rudern verletzt,' *he has hurt himself while rowing.* 'Ich musz nach der Stadt gehen,' *I have to go to town.*

C. *Governing an Accusative or Dative,* according to the meaning. The accusative is used when motion *towards* something is implied; the dative expresses rest, position, or motion *at* a place or *near* an object.

an, *on, at.*	über, *over, across.*
auf, *on, on to.*	unter, *under, among.*
hinter, *behind.*	vor, *before, in front of.*
in, *in, into.*	zwischen, *between.*
neben, *beside.*	

Examples.—'Kommen Sie, bitte, in den Garten!' *please come into the garden!* 'Waren Sie schon im (in unserem) Garten?' *have you been in our garden before?* 'Der Hund legte sich unter den Tisch, lag unter dem Tisch,' *the dog lay down (was lying) under the table.* 'Der Baum stand vor der Kirche,' *the tree stood in front of the church.* 'Der Baum wurde vor die Kirche gepflanzt,' *the tree was planted before the church.*

D. *Governing a Genitive only:*

(an)statt, *instead of.*	unweit, *not far from.*
trotz, *in spite of.*	während, *during.*
um-willen, *for the sake of.*	wegen, *because of, on account of.*

Examples.—'Trotz des Verbotes,' *in spite of the prohibition.* 'Während des Sommers,' *during (the) summer.* 'Wegen der Hitze,' *on account of the heat.*

Note the following contractions: 'ans, aufs, ins, durchs, fürs, ums = an das,' &c.; 'am, beim, im, vom, zum = an dem,' &c.; 'zur = zu der.'

XXIII. *Notes on German Pronunciation.*[1]—A. *The Vowels.*—A vowel is either short or long. It is long—(1) when doubled: 'Meer,' *sea*; 'Boot,' *boat*; 'Schāf,' *sheep.* (2) When followed by *h*: 'mehr,' *more* (pronounced like 'Meer'); 'Rahm,' *cream*; 'Bohne,' *bean*; 'kühl,' *cool.* (3) When followed by a single consonant only: 'lesen,' *to read*; 'schlafen,' *to sleep*; 'Rose,' *rose*; 'Schule,' *school*; 'Käse,' *cheese.* (4) The combination *ie* stands for long *i* (*i.e.* it is pronounced as in *believe*): 'sieben,' *seven*; 'Biene,' *bee*; 'Wien,' *Vienna.*

All vowel sounds are *pure* sounds in German; the English long vowels are *diphthongs.*

Below are given the nearest English equivalents of the German vowels. An *h* after a symbol indicates a *long* vowel.

GERMAN.	ENGLISH.	EXAMPLES.
a	The short sound of *ah*, or like *u* in *fun*.	das (with a short vowel); Sand.
ah	As *a* in *father*.	Vater, *father*; Rasen, *lawn*.
ä	As *e* in *bed* (see *e*).	hätte; Äpfel, *apples*.
äh	As *e* in *where*.	Ähre, *ear* (*of corn*); schälen, *to peel*.
	As *e* in *bed* (see *ä*).	Bett, *bed*; kennen, *to know*.
	As the *first part* of the diphthong in *fate*.	Seele, *soul*; Kehle, *throat*; Rede, *speech*.
	As *i* in *bit*.	Kind, *child*; Kissen, *cushion*.
	As *ie* in *believe*, *ee* in *bee*.	ihm, (*to*) *him*; Ziege, *goat*.
	Similar to *o* in *hot*.	Gott, *God*; Sonne, *sun*.
	Similar to the first element of the diphthong in *note*.	Sohn, *son*; Mond, *moon* (exception).
u	As *u* in *full*.	Butter, *butter*; Zunge, *tongue*.
uh	As *oo* in *moon*.	Kuh, *cow*; Stuhl, *chair*.
au	As *ou* in *house*.	Haus, *house*; Baum, *tree*.
äu } *eu* }	As *oi* in *boil*.	Häuser, *houses*; Eule, *owl*.

[1] German spelling is much more *phonetic* than English.

ö is the same as *eu* in French *peuple:* 'Götter,' *gods;* 'können,' *to be able to;* 'Löffel,' *spoon.*

öh is the same as *eu* in French *peu:* 'Söhne,' *sons;* 'lösen,' *to loosen;* 'König,' *king.*

ü is the same as *u* in French *lune,* but short: 'Sünde,' *sin;* 'Stück,' *piece;* 'Schlüssel,' *key.*

üh is the same as *u* in French *lune,* but long: 'Mühle,' *mill;* 'müde,' *tired;* 'kühn,' *bold.*

The letter *y* occurs only in words of foreign, chiefly Greek, origin. It is pronounced like *i* or *ü.*

Note that vowel sounds are *not* affected by a following *r,* but always pronounced in the same manner. Thus 'mehr' has the same vowel as 'lesen.'

B. *Consonants.*—All consonants not mentioned are to be pronounced as in English.

c before *a, ä, e, i, ü, ö* = *ts,* before all other letters = *k.* This letter is now used in foreign words and proper names only. 'Cöln,' also spelt 'Köln' (*Cologne*), is pronounced with *k.*

g is always hard: 'gehen, Gift.' (In some parts of Germany it is pronounced as a spirant.)

h is not sounded when it stands between vowels in the middle of a word: 'gehen = geh-en.' The combination *th* (now in foreign words and proper only) is = *t.* The sound of English *th* is not found in German.

j = English *y* in *young:* 'ja,' *yes;* 'Jude,' *Jew.*

qu = English *kv:* 'Quelle,' *spring, fountain.*

r should always be trilled with the tongue, or rolled with the uvula in the throat. The habit of pronouncing this sound like a spirant (= *g* or *ch*) is spreading in Germany.

s = English *z,* except when final. Initial *s* (in 'Seele,' *soul,* &c.) is always pronounced soft, as *z* in *zeal.* It is always hard when final, as in 'Haus' (*s* = *ss*), 'Hauses' (genitive, first *s* = *z,* second *s* = *ss*).

is always = *ss.*

st, sp, at the beginning of a word are = *sht, ship:* 'Stein,' *stone;* 'spielen,' *to play.*

v = *f* in words of German origin: 'Vater,' *father;* 'Vogel,' *bird;* 'viel,' *much;* 'vier,' *four;* and in a number of words now completely Germanised, as: 'Veilchen,' *violet;* 'Vers,' *verse.* In foreign words it is usually pronounced *v:* 'Lokomotive, Veranda,' 'Klavier,' *piano,* &c.

w = English *v,* as in 'wissen,' *to know;* 'Wasser,' *water.*

z and *tz* = English *ts:* 'zahm,' *tame,* for example, is pronounced *tsahm;* 'zwei,' *two* = *tsvay,* &c.

ch after *ä, e, ei, eu, äu, i, ö, ü,* is pronounced like a voiceless or hard *y,* or like an exaggerated *h* in *human.*

ch after *a, au, o, u* = Scotch *ch* in *loch.*

chs is = *ks,* if both *ch* and *s* belong to the stem of the word, as in 'Ochs,' *ox;* 'Fuchs,' *fox;* 'sechs,' *six.* If the *s* is merely added as an ending, as in 'des Reichs' (or 'Reiches'), the *ch* is pronounced as usual.

ng is never pronounced with an additional hard *g.* It is sounded like *ng* in *sing, singer* (not as in *finger*).

Note.—It is important to note that final *b, d,* and *g* are always pronounced hard—*i.e.* like *p, t, k.* The latter is also pronounced like *ch* by a large number of speakers. Thus 'Leib,' *body,* is pronounced *leip;* 'Wald,' *wood, forest* = *valt;* 'Berg,' *mountain* = *berk* or *berch.* This is a very important rule.

Note that there is no *liaison,* as in English and French—*i.e.* the final consonant of a word is never run together with the initial vowel of the next. Every initial vowel (*e.g.* in 'Eisen,' *iron,* 'aber,' *but,* &c.) is preceded by a peculiar glottal sound or stop.

C. *Accentuation.*—The general rule is that the first syllable of a word has the accent: 'Ga′rtenhaus,' *garden-house;* 'a′breisen,' *to leave, depart;* 'Ap′felbaum,' *apple-tree.*

Exceptions.—(1) Foreign words keep the accent as in the language from which they are taken: 'Natio′n' (like *nazio′hn,* as *-tion* is always pronounced *-zio′hn*); 'Fami′lie'; 'marschie′ren,' &c.

(2) Words beginning with the inseparable prefixes take the accent on the syllable following the prefix: 'vergessen,' *to forget;* 'besprechen,' *to discuss.*

(3) The so-called Double Particles, consisting of two indeclinable words, have the accent on the second syllable: 'dana′ch,' *after that;* 'dami′t,' *with it* (*therewith*); 'wesha′lb,' *why, what for?* &c.

A SURVEY OF GERMAN LITERATURE

It has been usual for writers on German literature to distinguish two Classical Periods centring round the years 1200 and 1800 respectively. Wilhelm Scherer, in his brilliant *History of German Literature,* expresses an opinion that there were in reality three such epochs. Although nothing beyond the most meagre fragments remain of the actual productions of this earliest period of literary activity, its influence on later ages is such as to entitle us to speak of it in the highest terms. Scherer goes on to say, that if we regard the year 600 as the culminating point of the first classical period, the scheme of the history of German literature will at once become clear. The development proceeds in a regular curve of alternating rises and falls. The highest points are separated by periods of six hundred years each. Each culminating point

is naturally followed by a sinking of the curve; there is a descent until literature touches its lowest point, when, through internal and external influences, an improvement begins to show itself, leading up to another period of brilliant intellectual activity. We thus obtain the following scheme, which may serve as the groundwork of this brief survey:

I. *c.* 600.—First Classical Period (conjectural): *The Heroic Age.*
  c. 900.—Period of Stagnation (Old High German Period).
II. *c.* 1200.—Second Classical Period: *Period of the Great Epic Writers, and of 'Minnesang'* (Middle High German Period).
  c. 1500.—Literature degenerates into a medium of party strife; the coarse and vulgar reign supreme in secular poetry.
III. Third Classical Period: *Period of Highest Literary Achievement;* the real *Classical Age* of Lessing, Herder, Schiller, and Goethe.

I. The Heroic Age.—If one possessed more complete information about the Heroic Age, one might, perhaps, have reason to describe it as the most characteristically German of all periods. It was the time following the gigantic struggles of the migration; the heroic exploits of the leaders in that great movement had not yet been completely forgotten, but were on the point of passing into the realm of legendary lore. Christianity was slowly superseding the old heathen religion. Wodan, Freya, and the whole assemblage of mythological personages lost their divine attributes and were made into human heroes and heroines; and in the course of continued oral transmission, the historical saga blended with the mythological legend into an inextricable mass of popular story. The all too short fragments of the *Song of Hildebrant*, written down about 800, are the only specimens of that vast body of epic lore that has come down to us. It tells the story of a fight between father and son, the conflict between the stern sense of honour and parental love. The end is not preserved; but we gather that the outcome of the fight will be the tragic death of the son at the hands of his own father. This and other ballad epics lived on in the memory of the people, to make their reappearance in a slightly altered form in the twelfth and thirteenth centuries. The best known of these is the *Nibelungenlied* (the Lay of the Nibelungs), which is often spoken of as the National Epic of the German race. In it are embodied the ideals and aspirations of the old genuine Teutons, unspoilt by contact with civilisation, but also untamed by the teaching of Christianity. Traces of the Indo-European mythology and nature-religion may be discovered everywhere in the rich and varied texture of this long epic. Siegfried, the hero, is the old sun-god, and Hagen, his murderer, represents the powers of darkness. Historical events, such as the invasion of Western Europe by the Huns and the destruction of the Burgundians, have contributed to the formation of the story. Other tales, mostly preserved in debased later prose-versions—for the taste for poetry was lost in the thirteenth century—relate the adventures of Dietrich von Bern (Theodoric the Great, whose capital was Verona); of Kudrun, a sea-king's daughter; of King Rother, who sailed to the Orient; of Laurin, king of the dwarfs, and many more. One of these epics dealing with Walter of Aquitaine was translated into Latin verse by a monk of St. Gall, and thus escaped oblivion.

A. The year 900 marks the lowest ebb of the older German literature. The Teutonic race had split up into various tribes, and the new nations were still in a state of transition. The high esteem in which the Latin language and literature were then held prevented the clergy, the only persons acquainted with the art of reading and writing, from cultivating their native idiom. Apart from dull and mechanical prose and verse paraphrases of the Scriptures, nothing of literary value is preserved from that dark period. One must, however, except the Low German *Heiland*, or *Saviour*, which is written in the old alliterative metre of the heroic age, and in which the author attempts to describe Christ as a German king, with apostles as His military followers, so that the story might be brought nearer home to the understanding of his hearers. It is a most interesting poem, the only one in the Low German idiom of any merit, and its author must have been well acquainted with both the contents and the diction of the National Epic. Another remarkable work of the same period is the Latin poem *Ruodlieb* (the hero's name), written by a monk in a Bavarian monastery, in which all the elements of the later romances, even of the modern novel, seem to be contained.

II. Period of Epic Writers and of 'Minnesang.'—The rise of chivalry is largely responsible for the flourishing state of German literature about the year 1200. The Crusades had brought all Western nations into closer contact, and had enlarged their vision by making them acquainted with the life and traditions of the Orient. French influence became for a time paramount in German higher society, and called forth the famous epics of chivalry for which that period is celebrated. Three great names are associated with this form of literature. Hartmann von Aue excels more as a master of language than an inspired poet. His polished verse served as a model for those coming after him. He seems to have originally been destined for the Church, and the effect of his monastic education may be

discovered throughout his works in his somewhat melancholy outlook upon life, and in the deeply religious tone of his moralising passages. The plots of his epics are all taken from foreign sources, chiefly French; and the same applies to both his compeers. This does not mean that they translated slavishly. They took over only the framework of the tale, the skeleton which they clad with flesh and blood of their own creation. In the re-telling of the events, they adhere with scrupulous care to the French originals; but in the character-drawing, in the ethical and philosophic treatment, they work as creative artists and thinkers.

Wolfram von Eschenbach, in his *Parsival*, pictures the noblest ideals and aspirations of chivalry, and his epic has been pronounced the greatest work of imagination produced by any mediæval poet. The hero, starting out on life's adventurous journey as the 'guileless fool,' pursues an aim similar to that of *Faust*, to whom he has often been compared. Wolfram expresses the central idea of his work more naively than does Goethe some six hundred years later. How is it possible, he asks, to combine our worldly aspirations with our duty towards God and religion? How can we live the life of the body without losing that of the soul? The answer, though only dimly indicated, is the same as in *Faust:*

Wer immer strebend sich bemüht,
Den können wir erlösen . . .

Parsival is brought up in complete ignorance of God and the world, and although at first he yields to the natural impulse of his passions, he is conscious of a dim desire for a higher life. This ideal he pursues, and nobly fighting his way through the darkness of doubt and despair, finally emerges into light, finding rest in the service of the Holy Grail. From this all too brief indication it must not be inferred that Wolfram's epic contains nothing but philosophic discussion. On the contrary, the poet delights in depicting real men and women, their passions and virtues; he leads us into the castles of the great, and into the camps of armies, into 'the romantic land of chivalry.'

The same may be said, perhaps with still greater justice, of Wolfram's contemporary, Gottfried von Strassburg, author of *Tristan and Isolde*. With regard to the 'moral purpose' of his work, he totally differs from the author of *Parsival*. He is frankly on the side of the worldlings. He tells us the story of the adulterous love of his hero and heroine without any moralising comments. It *was* so, he seems to say, implying that if two such beings were to meet again, the issue would surely be the same. Gottfried brilliantly represents that advanced section of mediæval society, in whom the 'doubt' so strongly condemned by the pious Wolfram had led to religious and moral libertinism. He writes from the point of view of men like the Emperor Frederick II, the ancestors of the typical Renaissance hero, whose conception of life is best expressed in Faust's words:

Das Drüben kann mich wenig kümmern;
Schlägst Du erst diese Welt in Trümmern,
Die andre mag darnach entstehn.
Aus dieser Erde quillen meine Freuden,
Und diese Sonne scheinet meinen Leiden. . . .

The National or Popular Epic has already been discussed. It has its roots in the Heroic Age, and now receives its final form. In the stream of lyrical poetry, where Walter von der Vogelweide occupies a pre-eminent position, two main currents have to be distinguished. The numerous writers of *Minnelieder*, love-lyrics, merely imitate a French genre that came into Germany in the train of chivalry. This originally Provençal type of poetry has for its main theme the praise of noble women, the cult of the female sex; but its sentiments no less than its form are almost wholly artificial. It is true that many of the best *Minnesingers* in Germany infused into their works some of the sincerity that should distinguish the true lyric; but it was reserved to Walter to write those exquisite little poems, having nothing of the conventional which pervades all troubadour minstrelsy, but which are in substance purely and simply the outpourings of his heart, only retaining the polished outward form of the fashionable poetry. He also wrote a large number of political ballads, passionate appeals for the unity of the German people, and for its resistance to papal interference in national affairs. These songs, couched in fiery language and perfect in verse and rhythm, travelled from one end of the country to the other, stirring the hearers to action, and thus performing the work of the more prosaic modern newspaper.

B. The Second Classical Period was entirely a creation of chivalry, of knightly society. When that society began to decay, its literature also rapidly declined. The thirteenth century witnesses the rise of the middle classes to power and self-respect, the ascendency of the town-dwellers, the burghers of the free and imperial cities, who now for the first time aspire to literary honours.

But this movement was not destined to produce any works of permanent value, at least not until, combined with other forces, it finally culminated in the glorious achievement of eighteenth-century classicism. The *Minnesang* deserted the stately halls and romantic castles of the knights and entered the walled cities of the Empire. In so doing it lost much: *Minnesang* turned into *Meistersang*. Love-poetry fell into the hands of sedate burghers, estimable men, to be sure, but pedantic in the extreme, of limited experience and puritanical in views. The old rules of versification were strictly adhered to, and just as the various trades had

formed closed guilds, so the writing of poetry was similarly organised into 'Schools.'

Composing and reciting poetry now became the holiday pastime of honest tradesmen and artisans. Among these 'poets,' only one, Hans Sachs, the cobbler of Nüremberg, is generally remembered. Living at the time of the Reformation, he had the courage to deviate from the rules of the school, confining the poet to strictly biblical subjects, and to write about current events. He was one of the first to hail the appearance of Luther, whom he describes, in the strange, overwrought allegorical fashion of the 'Meistersingers,' as the Wittenberg nightingale, whose beautiful song announces the coming of the dawn, driving away the powers of darkness and inaugurating the reign of light. Hans Sachs is chiefly remembered for his innumerable *Tales*, and rather coarse, but never lascivious, *Shrovetide Comedies* (*Fastnachtspiele*), many of which, with their quaint doggerel and vivid portraiture of contemporary characters, may still be read with enjoyment. Richard Wagner has immortalised the Nüremberg 'Meistersinger' and his companions in a work which by competent critics is considered to be his masterpiece.

The centuries following the Reformation are barren in works of lasting value. Satire of the coarsest description flourished; it was the period of the Gargantuan style of writing and thinking. The great upheaval, instead of lifting up the minds of men, had ended in creating two bitterly opposed factions, which conducted a violent controversy of calumny and vituperation couched in the language of Billingsgate. Brant's *Ship of Fools* ruthlessly attacks human nature in general, and contemporary society in particular, and so does the allegorical popular beast-fable, the Low German *Renard the Fox*. Both books were widely translated, and may be regarded as Germany's first contribution to world-literature.

While these things were happening on the surface, the voice of the simple people found expression in the rarely recorded *Volkslieder*, half-epic, half-lyrical in character. Very many of the best lyrics of this kind, for which Germany is justly famed, and which are contained in the collections of Herder, Arnim, and Brentano, Uhland, Erck, and others, go back to the fourteenth and fifteenth centuries. Closely bound up with the folk-songs is the religious hymn, which is the only form of real literature whose production was stimulated by the Reformation. Both in Protestant and Catholic circles, religious fervour found expression in beautiful verse, much of which survives in modern books of devotion. The names of the great Reformer himself, and of the Jesuit Angelus Silesius, may be mentioned in this connection. The importance of Luther's version of the Bible in the formation of the modern literary German language is discussed elsewhere.

When the first storm of the Reformation had blown over, signs of a literary revival made their appearance. But all hope of the rise of a national literature was destroyed by the awful calamity of the Thirty Years' War (1618–48). From it Germany emerged devastated, depopulated, mutilated in territory, and crushed in spirit. Grimmelshausen's powerful novel, *Simplizissimus*, with its harassing attention to detail, contains a true and horrible picture of the war, and is the only product of those troublous times that possesses permanent value.

The religious upheaval of the Reformation was preceded and accompanied by a revival of classical studies, by that Renaissance movement usually described as 'Humanism' when applied to the world of letters. Humanism had its roots in the universities, and was of an international character. It did not suffer so much from the effects of the war, and now became a powerful force in literature. Its immediate effects, however, were not altogether beneficial. The splendour of classical literature and art blinded men to the merits of their own native country's productions, just as it had done during the period following the introduction of Christianity. It also inspired an undue regard for the rules that they imagined governed Greek, and particularly Latin, poetry; and France having succeeded in building up a flourishing literature on the basis of these imaginary rules, the works of its poets were extolled as worthy of translation and imitation. We now enter upon a period which is characterised by a lack of national pride and self-reliance, by slavish adherence to foreign models, and by an undue estimation of the importance of external rules. The writing of poetry was considered a mere exercise of the intellect, an accomplishment that might be acquired by anyone, while genius was not regarded as a necessary qualification. This state of affairs is well illustrated by the grotesque title of a *Primer of Poetry*, which called itself *Nüremberg Funnel, for the pouring in of the Poetic Faculty in Six Hours* (1646). It was a work of dull imitations, of bombastic tragedies in Alexandrine verse, totally unsuited to the genius of the German language. Artificial and unreal pastoral poetry flourished and innumerable *Gelegenheitsgedichte*, occasional poems were composed with which even the most trivial events in public and private life were celebrated. At the beginning and end of this period we may fitly place two law-givers, pedantic critics who, themselves lacking divine inspiration, wrote treatises on the art of poetry, which they put into practice in works of no distinction. The elder and by far the more sympathetic one is Martin Opitz (1597–1639), who published his little treatise, *Buch von der deutschen Poeterei*, in 1624, and through it determined the character of German literature for several generations. Blind admiration of foreign models made him

transfer to German poetry the rules which French and Italian critics professed to have derived from Horace and Aristotle. If he sinned against the national spirit in many ways, he must be given credit for three important achievements. He confirmed the language of Luther in its supreme position as the medium of literature; he discouraged the indiscriminate introduction of foreign words; and reformed poetic rhythm, which had degenerated into a lawless doggerel during the centuries of depression.

The various 'schools' of poetry which literary historians distinguish in the seventeenth and early eighteenth centuries can be mentioned only briefly. They all own Opitz as their master: The first Silesian school, entirely given up to the imitation of foreign and classical models; the Königsberg or Prussian school, in which the influence of the unsophisticated *Volkslied* is slightly apparent; and the second Silesian, distinguished by the exceptional bombast of its style, its preference for the horrible and revolting, and its inclination towards the lascivious.

The Opitzian movement is brought to a close by another critic, the last man of note belonging to the formalistic school. Gottsched, the Leipzig dictator (1700–66), violently combated the excesses of the second Silesian school, and urged his countrymen to return to a stricter adherence to rule. His extremely narrow and uncompromising views were based on the works of the great French writers, Corneille, Racine, Molière, and Boileau, and for a time he ruled supreme and without opposition. About the year 1740, however, his ascendancy was effectively challenged by the Swiss critics Bodmer and Breitinger. The fight between the antagonists became very hot, and the controversies leading to the speedy downfall of the pedantic dictator were acrimonious in the extreme. Gottsched had declared that in poetry form alone mattered. Bodmer and Breitinger, however, dimly realised that poetic genius and animate fancy were after all more essential than the knowledge of formal rules. They further rendered an enormous service to their countrymen by directing their attention from French models to English writers, whose influence now begins to be powerful and beneficial. They were at one with Gottsched in insisting that literature should always have a moral purpose, and should 'imitate' nature, though they admitted, and even recommended, the 'wonderful' as a fit object of poetic treatment. Notwithstanding their own numerous shortcomings, they did useful work in breaking the spell of Gottsched's professorialism, and thus opening a path for the succeeding generation, who soon left both the Leipzig and Swiss censors still floundering in the morass of criticism.

III. Period of Highest Literary Achievement.— All these men wrote *about* poetry, and composed impossible verse without being poets themselves. The one to inaugurate the brilliant line of really inspired singers was *Klopstock* (1724–1803). He succeeded at last in harmoniously combining the three great forces in German contemporary mental activity: Christian piety, the national character, and the true spirit of classical antiquity. His poetry—the Miltonic epic *Der Messias* and numerous odes—produced an immediate and enormous effect on his contemporaries, who were pining for spiritual emotion after more than a century of arid rationalism. His writings do not, however, appeal in the same powerful way to subsequent and more realistic generations, who, admitting his greatness, fail to appreciate the exuberance of his imagination, which indeed too often loses itself in a vague infinity without shape or colour. The main themes of his poems are Christianity, Fatherland, Friendship, Love, and Nature. He is all sentiment; his characters lack individuality—they do not act, but merely feel. The keynote of his songs of love and friendship is a vague, sentimental yearning combined with a strong funereal strain.

By merely following the impulse of innate genius, regardless of critics and their rules, Klopstock set an example which was more valuable than either his choice of subjects or his method of treatment. He awakened a new national spirit, fortified the self-confidence of his countrymen, already encouraged by the brilliant victories of Frederic the Great. Klopstock fought against foreign influence by example; Lessing successfully continued the struggle by his active criticism. Having at first sided with the Swiss school, he soon turned to the direct study of Aristotle's critical writings. Homer and Shakespeare he declares the greatest of poets, and he defends them against the French and their followers. By examining their immortal masterpieces, he discovers the fundamental laws of art, and demands with irresistible fervour their application in a thoroughly national literature.

He devoted most of his energies to the reform of dramatic art. In his *Hamburgische Dramaturgie* he finally destroyed the superstition that the French classical tragedy and comedy were the only correct types of dramatic literature. Shakespeare was henceforth to be the model, if model there must be. Lessing's other manifold activities as historian, antiquary, philologist, enlightened theologian, must be passed over here. Whatever he touched, he handled with brilliant success. He proved himself the acutest of critics and dialecticians, a man of immense and comprehensive learning—in short, the finest and final product of eighteenth-century rationalism. Continuing what Luther so brilliantly inaugurated, Lessing perfected modern German prose, and if, on his own confession, he was not an inspired poet himself, he must yet be

regarded as the virtual founder of German classical drama.

Lessing forms a link between the old and the new, and the same may be said of Wieland (1733–1813), though in a different sense. The latter, too, came under the strong influence of English literature; but he modelled his style chiefly on contemporary French writers, whose light, scoffing, and even frivolous tone he often imitates. The most remarkable among his works are *Die Abderiten*, a novel containing in Greek disguise a humorous travesty of the life in a German *Kleinstadt;* and a romantic verse epic, *Oberon*, of which Goethe said that wherever poetry was appreciated, it would be loved and admired as a masterpiece of the art. Although most of Wieland's numerous novels and verse epics have long since ceased to be generally read, he has influenced the development of German literature considerably. Steering a middle course between Gottsched's strict formalism and Klopstock's excessive boldness of diction and loftiness of subject, he freed poetry from the pedantry of the former, and the extravagances of the latter. If Lessing is the father of modern prose, Wieland must be regarded as the creator of that poetic language which in the hands of Goethe and subsequent lyricists was turned to such admirable use.

The common feature of Klopstock, Lessing, and Wieland is the revolt against tradition, and the assertion of the rights of individuality. This sentiment was by no means confined to Germany. In all West European nations, a similar impulse made itself felt. Rousseau denounced civilisation as having demoralised humanity, and fervently preached the return to nature. In France the ferment broke out in political action, and the Revolution swept away the old institutions. The German citizen was debarred by the peculiar conditions of his country from taking part in politics. After the conclusion of the Seven Years' War, a long peace of thirty years' duration set in; but it did not bring with it the political union of the nation, which remained divided and without a voice in the government of the 350 odd states of the Holy Roman Empire. Activity was only possible in the field of intellectual pursuits. Schiller expresses this in several places, calling upon his countrymen to leave behind life's harassing worries and seek refuge in the land of the ideal, where alone real freedom may be enjoyed: *Werft die Angst des Irdischen von euch—Fliehet aus dem engen dumpfen Leben—In des Ideales Reich.* The spirit of patriotism called forth by Napoleon's oppressive policy, which was later on to take such effective form in the wars of liberation (1813–15), and which inspired the songs of Körner, Schenkendorff, and Arndt, had not yet become a force in national life.

In the seventies of the eighteenth century, the critical years of the 'Storm and Stress Movement,' the long pent-up energies of the nation broke loose and flooded the country with a mass of writings, most of which are now happily forgotten. Klinger's wild drama, *Sturm und Drang*, supplied later historians with a name for the movement, which in its own day was appropriately described as the *Geniezeit.* The spirit of free criticism had broken down all authority. Restraint of any kind was impatiently resented, and the time-worn institutions of society and organised religion were attacked and repudiated. Klinger, Wagner, Lenz, and the two Counts Stolberg may be named as members of that turbulent throng of writers, whose wild exuberance of spirit combined with strange eccentricities of conduct earned for them the name of 'original' or 'power geniuses' —*Original oder Kraftgenies.* Both Schiller and Goethe were drawn into the maelstrom, the latter being for a time the acknowledged leader of the wildest section. His novel, *Werther*, is the most notable and thoroughly characteristic product of that period, next to which we may place Schiller's *Räuber* and *Kabale und Liebe.* All three are masterpieces of enduring value. The stupid ridicule sometimes cast upon these works is totally uncalled for, and no one with a sense of true literary merit will fail to appreciate their high qualities. *Werther* took the world by storm; it was translated into almost every European language, and it was one of Napoleon's favourite books.

When the flood of the *Genieperiode* at last subsided, many of the most prominent and unruly among the young writers settled down in orthodox fashion; others are no more heard of. But there emerged from their ranks three men, the pride and glory of German literature: Herder, Schiller, and Goethe. *Herder* (1744–1803), the oldest of the three, is remarkable not for original and creative genius, but for his critical insight, as great if not greater than Lessing's. In the latter's mental constitution intellect and reasoning power prevailed. Herder's strength, however, lies in his unfailing æsthetic sense and unequalled faculty of recognising the great and essential in all art. Following the main current of contemporary thought, he enthusiastically emphasized the supreme importance of 'originality,' without committing himself to the extravagant notions of the *Kraftgenien.* In opposition to the formalist school, which declared poetry to be the 'invention' of mankind, he maintained that, on the contrary, poetry was older than prose. He calls it the 'universal language of the human race'; he points out that its best models are to be found in the popular poetry of all nations. He opened up the fountains of true and original poetry by fervently advocating the study of the Old Testament, of Homer, of Ossian, Shakespeare, and the folk-songs of all peoples, which latter he collected into an important volume, *Stimmen*

der Völker in Liedern. Herder's influence on his contemporaries was very marked. Goethe, for example, was deeply affected by his writings and personality.

It is quite impossible to give here anything like an adequate idea of the importance of **Goethe**, the greatest among German writers (1749–1832). In his long literary career, three periods may be distinguished. The first, ending with his arrival at Weimar (1775), may be called the period of storm and stress, and his chief production of those years, *Werther*, has already been mentioned. He was called to Weimar by the enlightened young duke, Karl August, sovereign of that miniature state, and as a consequence of this act the small Thuringian Court became the centre of German classical literature. Wieland was already there; Herder was brought to Weimar by Goethe; and Schiller soon followed. The second, or classical, period of Goethe's activity culminates in his acquaintance with **Schiller** (1759–1805), and may be said to terminate with the latter's death. These years saw the production of his great masterpieces—*Iphigenia, Tasso, Wilhelm Meister, Hermann und Dorothea,* and the first part of *Faust.* Schiller, having outgrown both the style and the extravagances of his early works, produced those dramas that will ever be the pride of the German stage—*Don Carlos, Wallenstein, Wilhelm Tell,* and others.

If we ask ourselves what it is that constitutes the perennial charm and imperishable value of these works, the answer must be: It is the perfect expression of the ideal of humanity therein expressed. Animated by the loftiest ideals, but free from prejudice of any kind, poetic genius of the highest order here undertakes to review and analyse human nature, endeavouring to comprehend and interpret in works of supreme artistic merit the mystery of life, and solve the riddle of human existence.

Of the two poets, Schiller is perhaps still the most popular in his own country, and is often called the national poet; but the highly wrought-up pathos of his dramas, ballads, and 'philosophic lyrics'—a genus peculiarly his own—do not appeal to foreign readers in the same way as do the artistically finished works of the more tranquil, essentially human Goethe.

Goethe's third period, from Schiller's death to his own, is a quiet garnering in of the fruits of a long and eventful life. His work will perhaps be best understood when one remembers that he himself described them as 'one long confession.' Whatever agitates his mind—his sorrows, joys, doubts, and struggles—he lays down in his poetry; and apart from *Faust*, the second part of which he did not finish until a few days before his death, he is at his best in his exquisite lyrics, which are unequalled in the world's literature.

By the side of the classical authors of the Weimar circle there had arisen out of the storm and stress movement another school of writers, whom it was the fashion to call the *Romanticists.* Here again we must distinguish between the critics and pathfinders, the brothers Schlegel, and the poets who put their ideas into practice. The Romantic movement is born out of the desire for a 'return to nature,' for a more national life, and a more complete union of poetry and life. But it sought to attain these ends in an artificial way. The chief features of the romantic school are: (1) The cult of the past, especially the Middle Ages; (2) the cult of the eccentric, the extravagant and the palpably unreasonable and impossible. The Middle Ages, with their imaginative splendour, their Gothic cathedrals, picturesque castles, their tales of wonder, adventure, and heroic achievement, appealed to the romantic mind by their contrast with the drab, monotonous aspect of contemporary life. The Middle Ages were the ideal period, whose departure they deplored, and in whose contemplation they revelled. Excepting a few lyrics, little is now generally read of the works of the Schlegels, Tiecks, Novalis, and their associates. The eccentric stories of Hoffmann and Kleist's dramas, however, have recently again risen in public esteem; and the lyrics of Eichendorff will only perish with the German language. But then neither Hoffmann, nor Kleist or Eichendorff, may be called romanticists in the accepted sense of the word. The more enduring fame of W. Schlegel and Tieck is based on their translation of Shakespeare, a marvellously accurate and yet poetic rendering, which has made the great British dramatist almost into a German classic. Stimulated by the romantic movement and its veneration of the productions of past ages, Arnim and Brentano, and after them Uhland, collected the German *Volkslieder,* whilst the brothers Grimm compiled the marvellous book of fairy-tales which has earned them world-wide fame.

It cannot be the object of this brief survey to deal at any length with the post-romantic movements. The men of the most recent period—the period in which we are living—have not yet been assigned their definite places in the temple of fame. It is impossible, however, not to say a few words about **Heinrich Heine** (1797–1856), who is held in much higher esteem abroad than he is in his own country, thus being the exact reverse of Lord Byron, esteemed by continental nations more than by his own. No one will deny that Heine was a great and gifted poet—one of the best lyric geniuses the world has ever produced. But his objectionable qualities—his biting sarcasm, his vindictiveness that recoils at nothing, the intensely realistic outlook upon life characteristic of the Jewish race—are perhaps more easily discovered and more deeply resented by his own countrymen than by foreigners.

The pity is that the worship of Heine seems to have blinded people to the merits of those great German singers that come after Goethe—Mörike, Annette von Droste, Theodor Storm, Liliencron, and many more.

German literature of to-day is in a condition of ferment. All the traditional forms of composition—the epic, the novel, and, above all, the lyric and the drama—are being experimented with to express the spirit of the age. The young generation of authors is pursuing this aim with much earnestness, and in some cases with success. In fact, a high authority has recently declared that of all European literatures, the German was the most modern in character and ideals, and that it best represented the tendencies of present-day thought.

COURSE OF READING

German literature is best approached through a study of Goethe, 'the head and body of the German nation' (Emerson). An excellent little book for this purpose is Herford's *Goethe* (The People's Books); Robertson's *Goethe and the Twentieth Century* (Cambridge Manuals) is equally valuable. Robertson's *Literature of Germany*, or his larger *History of German Literature* are very useful books. A very stimulating and well-written work is Franke's *German Literature, as Determined by Social Forces*. The best work in German is Scherer's *Geschichte der deutschen Literatur*, of which there exists an English version.

There are but few translations of the German classics; many of the translations have appeared in Bohn's Library, but they are very bad as a rule, and cannot in any way replace the originals.

Most of the German writers are available in cheap reprints, brought out by the firms of Cotta, Brockhaus, Hesse, Bong, and others. Single works can be obtained in the Reclam edition, which is the most representative.

Collitz, *Selections from German Classical Writers*, can be recommended. Anthologies of lyric poetry are *Die Ernte*, and Fiedler's *Oxford Book of German Verse*.

Particulars of editions of older writers will be found in the bibliographical appendix of Vogt and Koch's *Geschichte der deutschen Literatur*.

ESPERANTO

In every sphere of human activity two divergent principles present their claims—the principle of specialisation and the principle of co-ordination. These principles are not hostile, but are truly complementary. The microscope has its counterpart in the telescope; the scientist and the metaphysician are allies in the cause of truth. It is only comparatively recently that this omnipresent problem has manifested itself explicitly in the universal theatre of human society. The more we hear of the inviolability of the principle of nationality, the more do we hear of the validity of the principle of internationality. Esperanto is a linguistic instrument for international development, which neither violates nor impairs the course of national development. Its function is to coordinate national progress by facilitating international intercommunication.

There have been false prophets in our midst. During the last fifty years it has been repeatedly proclaimed that national barriers have been finally undermined by the engines of modern science. The nations, we were told, are in the melting-pot, and a true cosmopolitan people are in the making, embarrassed with neither household gods nor local spirits. Nor were there lacking signs of this seeming truth. Means of international communication increased with alarming rapidity. The telegraph, the aeroplane, the telephone, the steam-engine, the steamship, the motor, seemed verily to have pronounced a last requiem on the petty patriotism of petty peoples. And yet we are confronted with the coexistence of the opposite tendency—the assertion of national spirit increasing in proportion to the intensification of international sentiment. Recent European history exhibits a progressive disintegration of composite countries according to the principle of nationality. Recent wars reveal the overwhelming influence of national sentiment on the *morale* of armies. National sentiment does and will survive; and it is because Esperanto, the international auxiliary language, offers no violation to the legitimate claims of nationality that it has enjoyed and deserved such halcyon success. Note well that phrase, "international auxiliary language," for it epitomises the claims of Esperanto. The language was created as an international means of communication, and is not intended in anywise to supersede or destroy the national and domestic use of existing languages.

Necessity of an International Language.—It is only logical, before we weigh Esperanto in the balance at all, first to establish the fact that an independent international language is a real necessity. Why do we not accept one of the existing languages or resuscitate one of the dead languages to answer our purpose, granted that national isolation is no longer possible? If we happen to be English, the peculiar fitness of English will naturally suggest itself. Here ready to hand is the perfect instrument, by using which we do not commit ourselves to the impropriety and perilous responsibility of a special linguistic creation.

The arguments cited in favour of the adoption of English are familiar. The interests of English-speaking peoples are far greater than any other group of nations using a common speech. Moreover, English has, to a large extent, established itself as a means of communication with the East. The language, too, in structural evolution is more advanced than its European neighbours. It is answered that, though in currency English has considerable ascendancy, English-speaking peoples are nevertheless in a small minority when compared with the whole mass of civilised nations. Moreover, the *amour propre* of the more prominent of these rival claimants will never brook, and will successfully resist, the effrontery of such a national imposition. Surely it only shows gross lack of discernment and sympathetic obtuseness to make such claims for English to linguistic universality. The condition of things in the East, too, rapidly alters, and disintegration and national reassertion are inevitable. The spirit of nationality is sacrosanct, and all international movements must keep this in view.

But apart from national objections to their preferment, none of the living languages possess the intrinsic qualities necessary for the supreme international office. An international language must be easily acquired by all. Simplicity and regularity must be its essence. Living languages do not possess these essentials. As to the ancient languages, in their classic purity their structure is prohibitively complex. When simplified, rectified, and brought up to date in vocabulary, the result is a barbarous anomaly that commends itself to neither the learned nor the unlearned. An international language, therefore, must be neutral, and simple, regular, and homogeneous in construction.

The objector may grant that none of the existing national languages has all the requisites of a perfect international means of communication, but may not feel convinced that the demand for any innovated language is real and urgent; or, acknowledging the imperfection of the existing system of communication between nations, and acknowledging the need of greater linguistic facilities, he may prefer to await a natural linguistic evolution towards homogeneity and perfection rather than invoke a *deus ex machina* in the shape of a purely arbitrary and artificial linguistic creation. The demand for a complete international understanding is felt everywhere. Travelling, commerce, and art are incalculably handicapped by the language barrier. The case of science is less self-evident, but none the less the loss occasioned by the existing state of Babel to its furtherance and achievements is incalculable. Science is by its very nature neutral: its results become common property of all the peoples, but the present process of research is wasteful in time and material. Scientists in different countries are working, unknown to each other, on the same problems, and consequently there is conspicuous overlapping of results. Cases have been found where a lifetime has been devoted to the solution of a problem which, unknown to the experimenter, had already been solved in another country.

If all important results were recorded in the international language as well as in the national, the whole world's endeavour would be co-ordinated and systematised. As it is, the experimenter either labours in unenlightened isolation, or is compelled to devote months and years to acquire languages in order to get into touch with alien research. The demand for special scientific treatises in the various countries is small, and translations are consequently expensive. The translator, too, is seldom thoroughly conversant with the subject-matter. A translation into the universal language could be made once for all under the surveillance of the specialist; and the demand in the universal market would be sufficient to ensure cheapness of production. Those who have been present at an international scientific congress will be fully aware of the hopelessness of the multilingual system. By the confusion of tongues the very end of an international congress is defeated. Very different are congresses conducted in Esperanto. Again, by the adoption of an international language the standardisation of technical and scientific terms would be achieved with highly beneficial results. The suppositional promise of a naturally evolved international language need not detain us. There is no evidence of the coming event in fact.

The idea of an international language is not a contemporary innovation. Such languages have existed from time to time, but have invariably failed because they did not exhibit the two first necessities—neutrality and simplicity. In the Macedonian age Greek became the "common tongue" of half the known world. The Roman Empire tried to impose the Latin language, as well as Latin institutions, upon half the globe. In the Middle Ages Latin was the universal language of scholars, but its idiom became outraged and debased, and its vocabulary corrupted, when forced into new channels of learning. French for long was the universally adopted currency in diplomatic and artistic circles. In the Middle Ages various attempts were also made to build an *artificial* universal language. The schemes were based on the impossible idea that by classification and subdivision a complete knowledge of the universe might be obtained. A language built on the "philosophic" system would be self-explanatory when one was familiar with the principle of classification, the various letters indicating the genus, species, and subdivision in order. Languages of this type are designated *a priori* languages. They prove quite unpractical. Opposed to them is the type of artificial language called *a posteriori*. Such languages are composite. They borrow their vocabulary from existing roots, but their grammar and syntax are artificial in their homogeneity and regularity. To this type of language Esperanto belongs.

Other International Languages.—Of all artificial languages, excepting Esperanto, *Volapük* alone obtained any significant measure of international currency. This language was the invention of a Roman Catholic bishop named Schleyer, who was curé of Litzelstettin, near Constance. Its name is derived from the English words *world* and *speech*. It was too arbitrary and modificatory in its adoption of existing roots, as the name alone proves. The language was published in 1880, and it soon became widely popular in the leading countries of Europe. Ten years after its publication, in the height of its prosperity, it is said to have numbered a million adherents. Its decline was as rapid as its rise. An International Academy of Volapük was founded in 1887, but the house became divided against itself and could not stand. Modifications and improvements were suggested, and dissension arose as to their acceptance. Eventually the director, in opposition to the inventor, failing to carry his scheme for a reformed grammar, resigned.

Various Volapük academicians commenced constructing independent international languages. Meantime the rump Academy set to work on an entirely new language called *Idiom Neutral*. The report of the American Philosophical Society on Volapük is instructive in content. While the report fully acknowledges the urgency of the demand for an international auxiliary language, it rejects Volapük as inadequate for the purpose. It criticises it as being too arbitrary in construction, not inter-

national enough in vocabulary, and too synthetic in grammar. Thus died Volapük. Its life was short, but not in vain, for it showed that in an artificial language which is not fully established alterations are fatal.

Esperanto did not neglect the warning. It tolerates no faction or dissension. This inadmissibility of change that characterises Esperanto is not a proof of a stubborn dogmatism. Esperanto lays no claims to acquired perfection—nay, it contemplates a *gradual* perfection. But until such time as Esperanto is officially adopted for international purposes, Esperantists absolutely refrain from any amendment of the fundamentals. When it is finally established, then the consensus of usage among its master-writers will reveal any modification that demands official recognition.

Æsthetic Objections to Artificial Languages.—We have yet to deal with the æsthetic objections to an international language. There are those who are ready to acknowledge that an international language is indeed a labour-saving machine of incalculable commercial and material advantage, but utterly reject and repudiate it as a vulgar and diabolical invention, whose adoption would crush all the beauty out of the speech and thoughts of men. They rhapsodise on the untold wealth of a natural language, the infinite suggestions of its every word, and the luxuriance of its spontaneous growth. The mechanical uniformity, the dull monotony of a linguistic machine, they proclaim, is abhorrent to anyone capable of appreciating the spirit of language; the concomitant levelling of persons and nations is intolerable. Esperantists reply that their language is not an end in itself. It is not intended to exhibit the æsthetic and historic interest of the living tongues. (It has beauty of its own in style and character, but of that anon.) The language is frankly utilitarian, and its purpose in life is to open the widest fields of thought and activity to the greatest number. As to the dullness of a general uniformity and the vandalism of the levelling process of internationalism, the complaint should be launched against modernity at large and not against Esperanto. Science, democracy, and universal education are responsible for the melting-pot that is alleged to be destroying all the beauty and poetry of living. But, after all, jeremiads on the inevitable are unprofitable. Machinery has come to stay; Esperanto has come to stay; and if they come to destroy they also come to create, and to liberate the minds of men for higher things, nobler things, and greater things than ever went before. "Ni inter popoloj la murojn detruos" ("We shall break down the walls between the peoples"); "Amo kaj vero ekregos sur tero" ("Love and truth shall begin their reign on earth").

The function of language is to express the thoughts and feelings of men. Natural languages are full of anomalies and redundancies, which are by-products of their historical production and have no intrinsic value. These must be eliminated in an adequate international language, but without impairing its function. Inflexions and syntax must be reduced to a minimum of simplicity. The language must be absolutely phonetic. Thus the chief difficulties that embarrass the learner of living languages will be obviated. In vocabulary the principle of maximum of internationality of roots commends itself. Does Esperanto fulfil these conditions?

Origin of Esperanto.—The inventor of Esperanto is a Polish doctor of Jewish extraction, Ludwig Lazarus Zamenhof, who was born in 1859 at Bielostock. Poland is a polyglot country, and has been the scene of tragic intestinal carnage. As a boy Zamenhof was convinced that a prime factor in interracial misunderstanding was the language barrier, and he resolved to devote his life to its removal. Zamenhof thus describes his early conceptions of his calling.[1] "I was born at Bielostock in the province of Grodno (Russia). This scene of my birth and childhood determined the direction of my future aspirations. In Bielostock the population consists of four diverse elements—Russians, Poles, Germans, and Jews. Each of these sections speaks a different language, and is in disagreement with the others. . . . I was brought up to be an idealist; I was taught that all men were brothers, yet at the same time my surroundings made me feel that *men* did not exist; there only existed Russians, Poles, Germans, Jews, and so forth. This state of affairs continually disquieted my young mind—though many, mayhap, will smile at such 'world-sorrow' in a child. And as it then appeared to me that 'grown-ups' were all-powerful, I said to myself that when I grew up I would abolish the evil.

"Gradually, of course, I became convinced that things are not accomplished as easily as appears to a child. One after another I abandoned various Utopian ideas of childhood, and retained only the dream of one language for all mankind. At an early stage I felt that this could only be some neutral language, belonging to none of the existing nations. When I left school at Bielostock and entered the classical academy at Warsaw, I was attracted for a time to the ancient languages, and dreamt of a day when I should travel through the world and with impassioned words persuade mankind to revive one of those languages for common use. Subsequently—I forget how—I came to the firm conviction that this too was impossible, and I began to have vague dreams of a new, artificial language.

"I then made various experiments, inventing rich artificial declensions, conjugations, &c.

[1] Translated from the Esperanto.

But a human language, with, as it appeared to me, its endless series of grammatical forms and its hundreds of thousands of words which made the big dictionaries so formidable, seemed such an artificial and colossal machine that I more than once said to myself, 'Away with dreams! This task is beyond the powers of man.' But nevertheless I kept returning to my dreams.

"I learned French and German as a child, and could not then make comparisons or draw conclusions; but when in the fifth class at the academy I commenced to study English, I was struck with the simplicity of the English grammar, and more so owing to the sudden change from Latin and Greek. I then saw that richness of grammatical forms is only a chance historical occurrence, and is not necessary in a language. Possessed by this idea, I began to examine my language and to reject the unnecessary forms, and I noticed that the grammar melted away in my hands till it became so small as to occupy, without violating the language itself, only a few pages.

"One day I chanced to notice the inscription *Svejcar-skaja* (drink-shop), and afterwards the sign *Konditor-skaja* (confection-shop). This word *skaja* interested me, and showed me that suffixes make it possible to form, from one original word, several other words which need not be separately learnt by heart. This idea took possession of me, and I suddenly felt the ground under my feet. A ray of light had fallen on the big dictionaries, and they began to diminish rapidly before my eyes."

While yet in his teens Zamenhof had created the nucleus of his new language. In 1878 he communicated his ideas to some of his friends. They became enthusiastic partisans, and meetings were held where the language was put to test of speech. But only encountering derision outside, gradually his adherents fell away, and Zamenhof found himself alone. Disappointed in the infidelity of his first confederates, Zamenhof resolved to labour in isolation. Zamenhof was an oculist by profession, and it was only in intervals of leisure, during his five years university course in medicine, that he was able to devote his energies to his beloved language ("kara lingvo"). For some years after Zamenhof had begun his medical practice he still laboured at his language. He tried at first to find a publisher who would undertake the cost of publication. Finally, in 1887, Zamenhof was able to issue his treatise at his own expense. The author adopted the pseudonym of Dr. Esperanto ("one who hopes"), and his book was entitled *Lingvo Internacia. Antaŭparolo kaj plena lernolibro.*

Spread of Esperanto.—Unlike Volapük, the progress of Esperanto was at first slow. The first Esperanto association was founded in Petrograd in 1892, under the name of *La Espero.* During the first decade of its life the adherents of Esperanto were mainly Russians, with a few German and Swedish sympathisers. In 1889 *La Esperantisto,* the pioneer Esperanto newspaper, commenced publication in Nüremberg under the auspices of Trompeter. Subsequently it was censored in Russia, owing to the collaboration of Count Tolstoi, and was transplanted to Upsala, under the name of *Lingvo Internacia.* It has been published in Paris since 1902. Another early Esperanto newspaper was *L'Espérantiste,* founded in 1898 at Epernay by the great French apostle of Esperanto, the Marquis de Beaufront. The Marquis, when he first became acquainted with Esperanto, was on the point of publishing an international language of his own, but recognising the marked superiority of Zamenhof's production, he magnanimously abandoned his own invention, and devoted his wide influence and indefatigable energy to the promotion of the Esperanto cause. The movement in France was vigorous and widespread, and to-day France remains in the vanguard of the battle. In 1902 the first English association was founded by Mr. Joseph Rhodes and Mr. Ellis, and in 1904 the British Esperanto Association was founded. The official organ of the association is *The British Esperantist.* In the year 1902 the Spanish association was formed. Esperanto had now earned world-wide acceptance, and became an established fact, worthy of recognition as an important contributory factor in modern national and international progress.

In 1905 the first international congress was held at Boulogne. Twenty different nationalities were present at this momentous assembly, where the language was put to a crucial test in song and debate and drama. The great majority of the audience were familiar with the language only from books, or from conversation with their compatriots. Would there linger in the international use of the language subtle national idiosyncrasies of accent and phraseology, making universal understanding of the spoken word difficult or impossible? A thrill of intense expectation ran through the assembly as Zamenhof rose for the first time to address a world-wide assembly in the international language. Every word rang clear and distinct, intelligible to all. The full vocalic endings and logical harmony of the language proved to the delighted listeners that Esperanto had a rare beauty of its own. Moreover, they felt that it possessed a something ineffably illusive, yet intrinsic—a *living spirit* of its own. The Esperanto congress became an annual event. In Geneva, in August 1906, the second was held. The great Cambridge Congress came in August 1907, and gave an immense impetus to the movement in England. Congresses at Dresden, Barcelona, Washington, Antwerp, Cracow, and Berne bring the sequence up to date. Adherents now number millions, and

their hand-clasp encircles the globe. In 1907 an International Esperantist Scientific Office was founded in Geneva. The object of the institution is to establish Esperanto as an officially recognised international medium for scientific purposes; its official organ is the *Internacia Scienca Revuo*. Numerous other associations are being formed by Esperantists who have special interests of an international character—*e.g.* the *Tutmonda Esperantista Kuracista Asoĉio* (the Universal Esperantist Medical Association), the *Tutmonda Katolika Unuiĝo Esperantista* (the Universal Catholic Esperantist Union). Esperanto, of course, is absolutely neutral, and dissociates itself from any fixed dogmas or ideas; its connection with any special movement is purely as a speech-medium. It has no *credo* of its own.

Esperantist Declaration.—At the Boulogne congress a *Declaration* was adopted, giving an official account of the aims and scope of Esperanto. The Declaration runs as follows:

Deklaracio.	*Declaration.*
Ĉar pri la esenco de Esperantismo multaj havas tre malveran ideon, tial ni subskribintoj, reprezentantoj de la Esperantismo en diversaj landoj de la mondo, kunvenintaj al la Internacia Kongreso Esperantista en Boulogne-sur-Mer, trovis necesa, laŭ la propono de la autoro de la lingvo Esperanto doni la sekvantan klarigon.	Because concerning the nature of Esperanto many have a very false idea, therefore we, the undersigned representatives of Esperanto in different countries of the world, having assembled together at the International Esperanto Congress in Boulogne-sur-Mer, have found it necessary, at the proposal of the author of the Esperanto language, to give the following explanation.
1. La Esperantismo estas penado disvastigi en la tuta mondo la uzadon de lingvo neutrale homa, kiu, "ne entrudante sin en la internan vivon de la popoloj kaj neniom celante elpuŝi la ekzistantajn lingvojn naciajn" donus al la homoj de malsamaj nacioj la eblon kompreniĝadi inter si, kiu povus servi kiel paciga lingvo de publikaj institucioj en tiuj landoj kie diversaj nacioj batalas inter si pri la lingvo, kaj en kiu povus esti publikigataj tiuj verkoj kiuj havas egalan intereson por ĉiuj popoloj.	1. Esperanto is essentially an attempt to divulge over the whole world a neutral language for human use which, "not intruding upon the internal life of the peoples, and in nowise seeking to drive out the existing languages," should give to men of different nations the power of being mutually comprehensible, which might serve as a pacific language for public institutions in those lands where different nations are in strife about their language, and in which might be published those works which have an equal interest for all peoples.
Ĉiu alia ideo aŭ espero kiun tiu aŭ alia Esperantisto, ligas kun la Esperantismo estos lia afero pure privata, por kiu la Esperantismo ne respondas.	Any other idea or hope which this or that Esperantist associates with Esperanto will be his purely personal affair, for which Esperanto is not responsible.
2. Ĉar en la nuna tempo neniu esploranto en la tuta mondo jam dubas pri tio, ke lingvo internacia povas esti nur lingvo arta, kaj ĉar, el ĉiuj multegaj provoj faritaj en la daŭro de la lastaj du centjaroj, ĉiuj prezentas nur teorajn projektoin, kaj lingvo efektive finita, ĉiu flanke elprovita, perfekte vivipova, kaj en ĉiuj rilatoj pleije tauga montriĝis nur unu sola lingvo, Esperanto, tial la amikoj de la ideo de lingvo internacia, konsciante ke teoria disputado kondukos al nenio kaj ke la celo povas esti atingita nur per laborado praktika, jam de longe ĉiuj grupiĝis ĉirkaŭ la sola lingvo, Esperanto, kaj laboras por ĝia disvastigado kaj riĉigado de ĝia literaturo.	2. Because at the present time no one reviewing the whole world doubts any longer that an international language can only be an artificial one, and because, of all the very numerous experiments made in the course of the last two hundred years, all offer merely theoretical solutions, and only one language, Esperanto, has shown itself to be effectively complete, fully tested on every side, perfectly capable of living use, and in every respect completely efficient, therefore the friends of the idea of international language, conscious that theoretical discussion will lead to nothing, and that its aim can only be attained by continuous practical labour, have long grouped themselves round one single language, Esperanto, and labour to disseminate it and enrich its labour.
3. Ĉar la autoro de la lingvo Esperanto tuj en la komenco rifuzis, unu fojon por ĉiam, ĉiujn personajn rajtojn kaj privilegiojn rilate tiun lingvon, tial Esperanto estas "nenies propraĵo" nek en rilato materiala, nek en rilato morala.	3. Because the author of the Esperanto language from the very beginning refused once for all all personal rights and privileges regarding the language, therefore Esperanto is "the property of no one," either in a material or moral connection.
Materiala mastro de tiu ĉi lingvo estas la tuta mondo kaj ĉiu deziranto povas eldonadi en au pri tiu ĉi lingvo ĉiajn verkon kiajn li deziras, kaj uzadi la lingvon por ĉiaj eblaj celoj: kiel spiritaj mastroj de tiu ĉi lingvo estos ĉiam rigardataj tiuj personoj kiuj de la mondo Esperantista estos konfesataj kiel la plej bonaj kaj la plej talentaj verkistoj de tiu ĉi lingvo.	The whole world is the material master of this language, and any one who desires can publish in or concerning this language any works of any kind he desires, and use the language for any conceivable object; those persons shall be regarded the spiritual masters of the language, who shall be recognised by the Esperantist world as the best and most talented users of the language.
4. Esperanto havas nenian personan leĝdonanton kaj dependas de neniu aparta homo. Ĉiuj opinioj kaj verkoj de la kreinto de Esperanto havas, simile al la opinioj kaj verkoj de ĉiu alia Esperantisto karakteron absolute privatan kaj por neniu devigan. La sola, unu fojon por ĉiam deviga por ĉiuj Esperantistoj, fundamento de la lingvo Esperanto estas la verketo *Fundamento de Esperanto* en kiu neniu havas la rajton fari ŝanĝon. Se iu dekliniĝas de la reguloj kaj modeloj donitaj en la dirita verko, li neniam povas pravigi sin per la vortoj "tiel deziras aŭ konsilas la aŭtoro de Esperanto." Ĉiun ideon, kiu ne povas esti oportune esprimata per tiu materialo kiu troviĝas en la *Fundamento de Esperanto* ĉiu havas la rajton esprimi en tia maniero, kiun li trovas la plej ĝusta, tiel same kiel estas farate en ĉiu alia lingvo. Sed pro plena unueco de la lingvo, al ĉiuj Esperantistoj estas rekomendate imitadi kiel eble plej multe tiun stilon kiu troviĝas en la verkoj de la kreinto de Esperanto, kiu la plej multe laboris por kaj en Esperanto, kaj la plej bone konas ĝian spiriton.	4. Esperanto has no personal lawgiver, and depends upon no particular individual. All opinions and works of the creator of Esperanto have, like the opinions and works of any other Esperantist, an absolutely private character, and are binding upon no one. The sole foundation of the Esperanto language, which is once for all binding upon all Esperantists, is the little work *Fundamento de Esperanto*, in which no one has the right to make any change. If any-one departs from the rules and models given in the said work, he can never justify himself with the words "So desires or counsels the author of Esperanto." In the case of any idea which cannot be conveniently expressed by means of that material which is contained in the *Fundamento de Esperanto*, every Esperantist has the right to express it in such manner as he considers the most suitable, just as is done in every other language. But for the sake of complete unity in the language, it is recommended to all Esperantists to imitate as far as possible that style which is found in the works of the creator of Esperanto, who laboured most abundantly for and in Esperanto, and who best knows the spirit of it.
5. Esperantisto estas nomata ĉiu persono kiu scias kaj uzas la lingvon Esperanto, tute egale por kiaj celoj li ĝin uzas. Apartenado al la aktiva Societo Esperantista por ĉiu Esperantisto estas rekomendinda, sed ne deviga.	5. The name of Esperantist is given to every person who knows and uses the Esperanto language, no matter for what purposes he uses it. Membership of some active Esperanto society is to be recommended for every Esperantist, but is not compulsory.

In 1905, at the congress at Boulogne, an Esperanto *Lingva Komitato* (Language Committee) was instituted. To this committee

questions are submitted by Esperantists, and reports are issued on points worthy of consideration. All decisions are the result of the members' voting. The committee is not authorised to make any alteration in the *Fundamento de Esperanto*, which is inviolable, but to guard and foster the development of the language, preserving its purity, directing its procedure, and establishing its universality.

Let it be here noted that when the word *universal* is applied to Esperanto it refers to its *auxiliary* use: Esperanto makes no claims to equality with the best of the living languages as a *literary* or domestic medium. It was largely because Volapük laid claim to being a literary language, capable of expressing all the subtle suggestions, all the atmospheric niceties, all the cumulative richness of the living medium, that the project failed. Living languages have a history; their past penetrates deeply into their present, colouring it with indescribable shades, enriching it with illusive perfumes. The content of the words varies. Words are as jars, which one century fills with roses, blushing and fragrant, and other centuries store for the bygone sweetness of their pot-pourri, or as old bottles into which the centuries pour new wine. Words of a living language are a ceaseless growth; their soul is not commensurable, their spirit is not confined. But it is the very essence of an international language that its words should be in their signification static, rigid, definite, invariable. Again, a living language is rich in synonyms, plenteous in gradations, while an artificial language aims at eliminating every superfluity. Esperanto conforms to the demands of the strictest logical economy, yet what it lacks in richness of synonyms and suggestion, it to a great extent supplies by its illimitable word-building powers. As an international medium it is unsurpassed, as a literary medium it has a new but highly potential spirit.

The natural evolution of the European languages shows a gradual simplification. A chief feature is the displacement of the synthetic by the analytic principle—*i.e.* the substitution of independent propositions and auxiliaries for the inflexional system. Contrast the intricate Latin and Greek declensions with the English invariable nominative with its auxiliary propositions. English is thus furthest advanced in the analytic development; French takes the next place; Russian, with its complicated inflexions, is well in the rear. Again, consider the article. Latin had none, but the want was a logical imperfection, and in its corrupt days Latin adopted one. Greek had an intricate Protean article, with highly involved functions. In the modern world Russian has no article. German has a clumsy multiform instrument; French has made jetsam of several articular encumbrances. English, the pioneer, has evolved the invariable and masterful *the*. Esperanto observes the law, and follows the direction.

Again, compare the arbitrary French and German rules of gender with the English laws moulded on the physiological sex-basis. In the abandonment of adjectival concords, too, English leads the way. But all these languages possess numerous irregularities, the inalienable legacy of the past: these irregularities are a stumbling-block to learners, and have no special logical function. (Be it noted, however, that, in obedience to the spirit of the age, modern additions to the vocabularies are invariably regular. Contrast, for example, *I see, I saw*, with *I telephone, I telephoned*. Slang frequently takes an independent step towards uniformity —e.g. *I dig, I dug*, in primary signification, but in slang signifying *lodge—I dig, I digged*.) If, however, English outdistances her rivals in grammatical simplification, she lags far behind in phonetic homogeneity. A rigid phonetic basis is essential for an international language.

ELEMENTS OF ESPERANTO

Phonetics.—How does Esperanto utilise the hints in lingual construction that the natural evolution of modern living languages offers? Esperanto is absolutely phonetic. One letter one sound is its working principle.

The *vowels* are *a, e, i, o, u*, pronounced *ah, eh, ee, oh, oo*. All are long.

Of the consonants, *b, d, f, h, k, l, m, n, p, r, t, v, z* are pronounced as in English, but

c is pronounced as			*ts* in English		*fits*
ĉ	,,	,,	*ch*	,,	*churn*
g	,,	,,	*g*	,,	*gap*
ĝ	,,	,,	*g*	,,	*germ*
ĥ	,,	,,	*ch*	,,	*loch*
j	,,	,,	*y*	,,	*yes*
ŝ	,,	,,	*sh*	,,	*trash*

There are three diphthongs:

aj pronounced as English			*eye*
oj	,,	,,	*oy* in *toy*
aŭ	,,	,,	*ow* in *cow*

(*eŭ* occurs occasionally)

The accent falls on the second last syllable.

Grammar.—The following is a skeleton of the fundamental rules of the grammar:

(1) Esperanto has only one definite article, *la*, which is the same for all genders, numbers, and cases.

(2) Nouns always end in *o*: *e.g.* 'parolo,' *speech*.

(3) Adjectives always end in *a*: *e.g.* 'simpla,' *simple*.

(4) The plural of nouns, adjectives, participles, and pronouns (except the personal pronouns) is formed by adding *j* to the nominative: *e.g.* 'domoj,' *houses*; 'bonaj homoj,' *good men*.

(5) The accusative case always ends in *n*: *e.g.* 'Mi amas mian bonan domon,' *I love my good home*; 'Ni amas niajn bonajn domojn,' *We love our good homes.*

(6) Derived adverbs end in *e*.

(7) The comparative is formed by prefixing the word 'pli' to adjectives and adverbs, and the superlative by 'plej': *e.g.* 'pli bona,' *better*; 'plej longe,' *furthest*. 'La plej bona patro,' *the best father*.

(8) The personal pronouns are:

mi = *I*	ŝi = *she*	ni = *we*
vi = *you*	ĝi = *it*	vi = *you*
li = *he*	oni = *one*	ili = *they*
	si = reflexive.	

These pronouns form the accusative by adding *n*, and the possessive case by adding the adjectival ending *a*.

(9) The cardinal numbers are: unu, du, tri, kvar, kvin, ses, sep, ok, naŭ, dek, cent, mil. Tens and hundreds are expressed by the juxtaposition of the numerals—*e.g.* 'tricent okdek du,' 382. Ordinals are formed by adding the adjectival ending *a*—*e.g.* 'dua,' *second*; 'deka,' *tenth*; 'centa,' *hundredth*. Multiples are formed by adding *obl* (*e.g.* 'duobla,' *double*), fractionals by adding *on* (*e.g.* 'dekono,' *a tenth*), collectives by adding *op* (*e.g.* 'triope,' *by threes*).

(10) Verbs are not changed for person or number.

The present tense ends in *as*: *e.g.* 'mi parolas,' *I speak*.

The past tense ends in *is*: *e.g.* 'vi parolis,' *you spoke*.

The future tense ends in *os*: *e.g.* 'li parolos,' *he will speak*.

The conditional ends in *us*: *e.g.* 'ni parolus,' *we should speak*.

The imperative ends in *u*: *e.g.* 'parolu,' *speak!* 'li parolu,' *let him speak*.

The infinitive ends in *i*: *e.g.* 'paroli,' *to speak*.

There are six participles.

The present participle active is formed by adding *ant*: *e.g.* 'parolanta,' *speaking*; 'parolanto,' *a speaker*.

The past participle active is formed by adding *int*: *e.g.* 'parolinta,' *having spoken*; 'la kreinto' (the man who has created), *the creator*, from the root 'kre,' *create*.

The future participle active is formed by adding *ont*: *e.g.* 'parolonta,' *about to speak*.

The present participle passive is formed by adding *at*: *e.g.* 'parolata,' *being spoken*.

The past participle passive is formed by adding *it*: *e.g.* 'parolita,' *having been spoken*.

The future participle passive is formed by adding *ot*: *e.g.* 'parolota,' *being about to be spoken*.

All compound tenses and the passive voice are formed by the verb 'esti,' *to be*, with a participle: *e.g.* 'mi estas parolanta,' *I was speaking*; 'ili estas parolontaj,' *they are about to speak*; 'ĝi estas parolata,' *it is spoken*; 'ĝi estas parolita,' *it has been spoken*; 'ĝi estas parolota,' *it is about to be spoken*.

(11) Compound words are formed by joining roots together: *e.g.* 'samideanoj,' *partisans of the same idea*; 'vaporŝipo,' *steamship*.

(12) 'Motion to' is expressed by the accusative: *e.g.* 'Mi iris domon,' *I went home*.

(13) The prepositions have each a definite meaning, except 'je,' which is used when the sense does not show which of the others should be employed. They govern the nominative, except when denoting motion: *e.g.* 'En la mondo,' *in the world*; 'en la mondon,' *into the world*. 'Li ridis je mi,' *He laughed at me*.

(14) The *a* of 'la' and the final *o* of the nominative can be dropped for euphony in poetry or conversation.

(15) Numerous prefixes and suffixes of definite meaning are used in word-building. The following are examples:

mal- (opposite): *e.g.* 'sana,' *healthy*; 'malsana,' *ill*.
ne- (negative): *e.g.* 'nesana,' *unwell*.
ig- (causative): *e.g.* 'lerni,' *to learn*; 'lernigi,' *to teach*; 'lerniga,' *instructive*.
ge- (of both sexes): *e.g.* 'sinjoroj,' *gentlemen*; 'gesinjoroj,' *ladies and gentlemen*.
re- (repetition): *e.g.* 'veni,' *to come*; 'reveni,' *to return*.
iĝ- (inceptive): *e.g.* 'fidi,' *to trust*; 'fidiĝi,' *to begin to trust*.
-ec (denoting an abstract quality): *e.g.* 'bona,' *good*; 'boneco,' *goodness*.
-ej (denoting place): *e.g.* 'vendi,' *to sell*; 'vendejo,' *a market-place*.
-ar (collective): *e.g.* 'vorto,' *a word*; 'vortaro,' *a vocabulary*.
-il (instrumental): *e.g.* 'razi,' *to shave*; 'razilo,' *a razor*.
-in (feminine): *e.g.* 'patro,' *father*; 'patrino,' *mother*.
-ebl (denoting possibility): *e.g.* 'kredi,' *to believe*; 'kredebla,' *credible*.
-ist (agent): *e.g.* 'Esperantisto,' *an Esperantist*.

Cases and Concords.—It is sometimes objected that Zamenhof did not carry the process of simplification far enough. Was it necessary to employ an accusative case? Why is the agreement of adjectives with substantives in number and case enforced? English has abandoned these constructions; is not their employment in Esperanto an anachronism? Zamenhof did not retain the accusative case and the agreement of adjectives lightly. He desired his language to be as flexible as possible and as logical as possible. Without agreement a definite order must be given in the sequence; with agreement any order can be followed with perfect lucidity. Where there is agreement, direct translations

can be made employing the natural sequence of wording of any language. Thus in English the arrangement of the sentence, *The boy the father loves,* leads to ambiguity, but in Esperanto, 'La knabo la patron amas,' the meaning is indubitable. There is a sacrifice, but the gain far outweighs the loss.

Vocabulary.—The vocabulary of Esperanto is built on Western foundations. This was inevitable. The roots were chosen upon the principle of *maximum of internationality.* The *Universala Vortaro* contains 2642 roots translated into French, English, German, Russian, and Polish. Thus those who run may read the degree of internationality in each. Certain root-words are completely international (in the European languages)—e.g. *atom-*, *danc-*, *flut-*, *vagon-*, and most scientific terms. Such words form the first class. The second class consists of root-words that are common to two or more European languages. The following examples (spelt phonetically) are selected by Dr. L. Couturat and Dr. L. Leau in the *Histoire de la Langue Universelle*: *flam-*, *marŝ-*, *mast-* (G., E., F., I., R., S.[1]); *ankr-* (G., E., F., I., R.); *benk-* (G., E., F., I., S.); *marmor-* (G., F., I., R., S.); *flor-* (E., F., I., S.); *jun-*, *artiŝok-*, *fason-* (G., E., F., R.); *mus-* (G., E., I., R.); *fam-* (E., I., S.); *flag-*, *stal-* (G., E., R.); *emajl-*, *mebl-*, *trotuar-* (G., F., R.); *man-* (F., I., S.); *mon-* (E., F.); *bind-*, *blind-*, *dank-*, *fajr-*, *fiŝ-*, *fingr-*, *glas-*, *help-*, *jar-*, *land-*, *melk-*, *rajt-*, *ring-*, *send-*, *ŝip-*, *ŝu-*, *sun-*, *trink-*, *varm-*, *verk-*, *vort-* (G., E.). The third class of root-words have no degree of internationality. These Zamenhof has borrowed from Latin, or from the principal national languages. Thus from Latin he has borrowed certain particles—e.g. *apud*, *dum*, *sed*, *tamen*, and root-words such as *aŭd-*, *brak-*, *dors-*, *dekstr-*, *feliĉ-*, *proksim-*; from the Germanic languages the root-words *bedaŭr-*, *bird-*, *fraŭl-*, *flug-*, *flik-*, *knab-*, *kugl-*, *ŝajn-*, *silk-*, *ŝirm-*, *sink-*, &c.; from the Slavonic languages the root-words *bulk-*, *brov-*, *prav-*, *selk-*, *svat-*, *vost-*, &c. Thus the language is rendered as impartial and international as possible. All can acquire it with ease; to the scholar with a knowledge of two or more European languages it is mere child's play.

The advantages gained by teaching children Esperanto as a basic language are far-reaching. Reasonable, logical, free from redundancies and anomalies, the language does not tax the memory, but stimulates intelligence. Moreover, it has a great constructive virtue. The child learns the necessary roots and the fundamentals of the grammar, and then proceeds to build the language up for himself. Surely the study is then encouraging to the child, and a blessed substitute for the disheartening maze of grammar and syntax that is usually presented to his bewildered mind. Having thus learned to appreciate the positive nature of word- and language-building, and the true logic of grammatical expression, the child enters the more difficult fields of the living languages with confidence and hope, knowing that here, too, are chartered lands, here, too, are familiar voices.

[1] German, English, French, Italian, Russian, Spanish.

The green star, emblem of Esperanto, is in the ascendant: it is the tutelar sign of a mighty birth. With ever-increasing volume *La Espero*, the *Hymn of Hope*, rings through the universe:

En la mondon venis nova sento
Tra la mondo iras forta voko;
Per flugiloj de facila vento
Nun de loko flugu ĝi al loko.

No al glavo sangon soifanta
Ĝi la homan tiras familion;
Al la mond' eterne militanta
Ĝi promesas sanktan harmonion.

Sub la sankta signo de l'espero
Kolektiĝas pacaj batalantoj,
Kaj rapide kreskas la afero
Per laboro de la esperantoj.

Forte staras muroj de miljaroj
Inter la popoloj dividitaj;
Sed dissaltos la obstinaj baroj,
Per la sankta amo disbatitaj.

Sur neŭtrala lingva fundamento,
Komprenante unu la alian,
La popoloj faros en konsento
Unu grandan rondon familian.

Nia diligenta kolegaro
En laboro paca ne laciĝos,
Ĝis la bela songo de l'homaro
Por eterna ben' efektiviĝos.

L. L. Zamenhof

Translation of the Above

Into the world has come a new feeling: through the world goes a mighty voice. On the wind's light wings now may it fly from place to place.

Not to the sword, thirsty of blood, it draws the human family. To the world eternally at strife it promises a sacred harmony.

Under the sacred sign of hope gather the warriors of peace, and swiftly spreads the cause through the labour of the hopeful.

Strong stand the walls of a thousand years between the sundered peoples, but the obstinate bars shall leap apart, by sacred love dissevered.

On the foundation of a common speech, understanding one another, the peoples shall make in concord one great family circle.

Our zealous company shall never weary in the labour of peace, till humanity's fair dream shall be realised with everlasting blessing.

Institutions.—The *British Esperanto Association* has its headquarters at 17 *Hart Street, London, W.C.* It is a union of Esperanto societies throughout the Empire, and has been established for the following purposes:

(*a*) The promotion of the formation of new local groups.

(*b*) The distribution of information and the publication of propaganda literature.

(*c*) Organisation of examinations and awarding of certificates of proficiency.

(*d*) The promotion of arrangements for congresses at home and abroad.

The Association consists of Members, Fellows, and affiliated groups. The annual subscription for membership is 5*s.*; Fellows, 10*s.* Members and Fellows receive the journal, *The British Esperantist*, free. The Esperanto badge is a five-pointed green star.

There is an international monetary system in use among Esperantists. The working unit in this notation is the *spesmilo*, equivalent to 2*s.* sterling (*e.g.* 5*s.* 6*d.* = Sm. 2·750).

COURSE OF READING

The following instruction books and literature are supplied by the *British Esperanto Association* at the following rates (including postage):

A. *In English.*—*Commentary* (Grammar, &c.), by Major-General George Cox, B.A., 2*s.* 6*d.* *Ekzercaro*, by Dr. Zamenhof, with key, 1*s.* *The Esperanto Teacher*, by Helen Fryer, 7½*d.* *Esperanto Manual*, by M. L. Jones, 1*s.* 1½*d.* *Esperanto in Fifty Lessons*, by Edmond Privat, 1*s.* 8*d.* These books are all recommended by the Association.

B. *In Esperanto.*—*Fundamento de Esperanto* (5-lingva), by Dr. Zamenhof, cloth, 3*s.*; paper, 2*s.* (This is the pioneer classic on Esperanto.) *Kursa Lernolibro*, by Edmond Privat, 6½*d.* *Legolibro por lernantoj*, by Dr. Fisher, 9*d.*

C. *Dictionaries and Phrase-books.*—*Esperanto-English Dictionary*, by Edward E. Millidge, 5*s.* 3*d.* (This is perhaps the best dictionary for English students.) *English-Esperanto*, by O'Connor and Hayes, 1*s.* 8*d.* *Universala Vortaro* (official edition), 6*d.*

Esperanto Literature.—The following is a selection from Esperanto literature (translations, &c.): *Fundamenta Krestomatio*, a collection of prose and poetry, edited by Dr. Zamenhof, the standard guide for Esperanto style, should be in the possession of every Esperantist; cloth, 4*s.* 6*d.*; paper, 3*s.* 6*d.* *Eneido* (Virgil's Æneid), translated by Dr. Vallienne, 3*s.* *Interrompita Kanto, La* (E. Orzeszko), translated by Kabe, 9*d.* *In Memoriam* (Tennyson), translated by A. E. Styler, 1*s.* 7*d.* *Nova Testamento* (New Testament), 1*s.* 9*d.* *Tri Mortoj* (Tolstoi), translated by M. Ŝidlovskaja, 4½*d.* *La Vendetta* (H. de Balzac), translated by M. Merckens, 1*s.* 3*d.* *La Avarulo* (Molière), translated by Sam. Meyer, 9*d.* *Hamlet*, translated by Dr. Zamenhof; paper, 2*s.* *Ifigenio en Taurido* (Goethe), translated by Dr. Zamenhof, 2*s.* A translation of the Old Testament by Dr. Zamenhof is now in the press.

The best book on the theory, aim, and scope of Esperanto is *International Language*, by Dr. W. T. Clark, M.A. (1*s.* 3*d.*). *The Passing of Babel*, by B. E. Long, B.A. (7*d.*), is also practical and instructive.

Alice E. Stirling, M.A.

IV. ART

PAINTING

THE painter is he who, seeing the world around him more intensely than the layman, is able to communicate his ideas to others. Nature is ready at hand to all; both artist and critic may be able to see the reality of the world; the artist alone can express himself. There are three factors in all art: the subject, which we call "nature"; the technique of the special art in question; the personal point of view of the artist. Nature in relation to art is passive. The scientist will tell you what is contained in nature—in prose if he is writing or on an Ordnance sheet. Technical ability and a point of view remain to the artist. He looks on nature with the eye of genius, and represents it through the medium of his technique. In the finished work of art the three factors are inseparable. The painter's aim is to represent what he sees, contrasted, it may be, with what he knows exists. A painting is a unit composed of various parts. Each little space of a picture represents a natural phenomenon, but must not be viewed alone. Its *raison d'être* is its relation to the picture as a whole. As one looks at the same thing from different standpoints the relations of the parts change under the different influences of the light. To the statistician or natural historian one haystack is the same to-day, yesterday and for ever; to the painter all is change. The various colours and gradations of colour in a picture have a content of their own just as the individual notes of a sonata, but they have a marked influence on those surrounding them, and their worth is known only when the whole is grasped.

Italian Paintings.—We have no space, and there is certainly no necessity, to attempt to show the origins of painting. Fresco, in which colours mixed with water are applied to wet plaster instead of being mixed with oil, at first held the field, and the influence of the earlier Byzantine mosaics, as you so easily study them in St. Mark's, Venice, is very pronounced. Art was then the chaste handmaiden of religion, and by the thirteenth century you find schools of artists in every Italian community. The subjects were prescribed, and wholly taken from the Bible or the legends of the Saints, and no innovations were thought of in the representation. Pupils followed for the most part the colours of their master and learned his tricks. Perspective and anatomy were unknown, but the primitive lack of reality which is so fascinating in mosaic, where it has never been surpassed, leaves the modern student cold in fresco. Soon, however, the Italian curiosity which is the basis of knowledge asserted itself. The faces of the portraits become more lifelike, the action less stilted, and the personality of the artist revealing itself, we come to the great names in Italian painting. It is well to warn the enthusiastic seeker of beauty in painting that in the modern sense these painters are not loved for their pictorial ability. Many external and non-artistic qualities are put down to their credit. In the first place they are interesting historically—anything "early" has always a fascination for some people. Again, a game has been played by experts, the aim of which is to discover names for painters hitherto unknown, and to subtract from the work of well-known men the pictures on which their fame rests. This is a wholly diverting amusement. Again, the subjects drawn from biblical or ecclesiastical lives interest many people theologically inclined, so you will read hundreds of books on the identification of the figures on an Italian picture and the reasons for their attitudes. From a biographical point of view much has been discovered by ingenious men about the artists themselves, and people as a rule are much more interested in the life of a painter than in his work, and Italy at this time was the centre of the universe.

Apart from these interests there remain as artistic qualities, graceful drawing and harmony of design, with a display of colour which, if you shut out all you know of the effect of light in nature, may prove agreeable. They should be considered, having regard to the conventions of the day, not as pictures, but as decorative

patterns having no reference to reality. Thus viewed, they do not impress so much as stained glass or mosaic, but in many cases fascinate.

The first painter with whom we shall deal is *Cimabue*, who lived in the last half of the twelfth century. It is of his "Madonna" that the well-known story is told, how it was carried in triumph from his studio to S. Maria Novella through the streets of Florence. In it you see the link between Byzantine mosaic, with their stiff, formal limbs, drapery, and expression. He was followed by *Giotto*, whom admirers of Ruskin will praise, and whose work is best seen in Padua, Assisi, and S. Croce, Florence. He has unfortunately been cruelly dealt with by time, which has faded his work and permitted restorers to destroy what was left, but you may still observe some attempt to express animation in the figures, balance in the grouping, reality in the action. On the other hand, even at this early stage you lose just that fascination of frankly conventional art which the post-impressionists of our day have so well brought out. Of his school the *Gaddis* are not impressive, but *Orcagna* in his "Heaven and Hell" in the Strozzi Chapel, Florence, proves his skill as a delineator of physiognomy. There are hundreds of painters of this period to whom we cannot give a name, many of as great accomplishment as the popular heroes, and it is not till the beginning of the fifteenth century that *Massaccio* appears and forewarns us of the Renaissance. His frescoes are best seen in the Carmine Church in Florence, and show us where the Raphael of the cartoons got much of his inspiration, and in them you will note the growing interest in and grasp of perspective. This latter was logically applied by his contemporary, *Paolo Ucello*, one of whose battle-pieces is in the National Gallery, a welcome relief to the religious attitudinising of the period. *D. Venezcano* (1400–1461), on the other hand, especially at S. Croce, and *A. del Castagno*, of whom the National Gallery has a "Crucifixion," show the desire for realistic expression. and the latter's pupil, *Piero della Francesca*, combines this with not a little poetical imagination. But all were not of this curious frame of mind, and among the orthodox painters of the day none are more deservedly famous than *Gentile di Fabriano* and *Fra Angelico*. The former's "Adoration of the Magi" in the Florence Academy shows a delightful sense of bright colour combined with frank portrayal of animal and flower life. Alongside of him, and still less interested in the intellectual movements of the day, is Fra Angelico, the pious monk of S. Marco. At Florence, where his best work in fresco is seen, by the richness of his colour, his sincerity of purpose, and his *naïveté* of expression, he endears himself to everybody. His realisation of religious feeling is, if not strong, by no means sentimental, and refreshing if compared with Raphael or del Sarto. If, as is no doubt common, the visitor to Florence, his mind filled with the noble story of Savonarola, seeks soon after his arrival some wonderful surrounding for so great a theme, and makes a solemn pilgrimage to S. Marco, or even mounts to Fiesole for the older monastery, he will receive a sore disappointment. This drab building is now a museum with all the fuss of a Government department, and makes him hasten to retrace his steps. But the sight of the pictures of the gentle Frate, who deemed himself unworthy of promotion even in the Church, will quell his emotions. He will not find, he must not look for realism of the figure, for scientific perspective, even for natural atmosphere; he will obtain the point of view of a joyous religious soul, as delicate an artist as the Bible illustrators of an earlier day.

Fra Angelico's vision is unique, but his technique is continued by his pupil *Gozzoli*, whose huge fresco in the Riccardo Palace is wholly delightful, with its laughing groups of boys and horsemen. There is a good specimen of his work in the National Gallery. A better known painter is *Fra Filippo Lippi*, chiefly from Browning's poem, the unorthodox monk. His influence on Botticelli is well marked, and the fascination the latter's pictures create is shared in a smaller way by the master. The human, wondering expression of the Madonna appears here for the first time. The choir of angels in his "Coronation of the Virgin" in the Florence Academy is well known, but more beautiful are his frescoes of the lives of John the Baptist and Stephen in the Prato Cathedral. But in every one of his works you will note marked characters in the faces, evidently studied from the life in the monastery or the street, the unconventional but apt and usually pictorial pose of the main figures. *Filipino* followed in his footsteps, but his greatest disciple is *Sandro Botticelli* (1447–1510), with whom there blooms the full Renaissance.

No attempt need here be made to discuss the origin of this great movement, but it would be foolish to ignore it altogether. It must always be remembered, in thinking of this Italian period, that we have to put out of our minds all we know of modern Italy, and consider only the communities living in the different towns. We may then picture a wave of enthusiasm for the old classical world, its literature and art, sweeping over Florence or Venice or Rome and inundating the minds of the citizens. Put away also our ideas of a capitalist society, and picture art not divorced from everyday life but the joy not only of a man's leisure but of his work, and not only of a few people but of everyone. Say it was the creature of religion or irreligion as you will, it is sufficient to note that it was closely entwined with the life of every Florentine, Pisan, or Veronese. Then you may take up the life of a Medici on the one hand and see how the artists

circled round a wealthy patron, or that of a Cellini and read how the travellers and craftsmen of all kinds, notwithstanding they were content with shops instead of studios, had art in all their thoughts. Then you shall understand that just as nowadays in certain communities one interest, that of football, is paramount, so in the Italian city of the time the spirit of the Renaissance in one form or another was never absent, nor shall you wonder at the Cimabue legend nor Cellini's account, exaggerated though it may be, of the setting up of his "Perseus" in the Loggia. Thus the Renaissance did not create art in Italy, but it concentrated the rather vague aspirations of the people—no small work. And apart from that, though Phidias was unknown to scholars then as now, and the Greek and Latin professed was not all of the classical period, yet a subtle feeling of eclecticism was engendered in such men as Botticelli, Leonardo, and Pico Mirandola, which will attract the minds and sense of all when Renaissance architecture and story are dead.

Botticelli is as good an example as one may wish of the spirit of the age. In him you note as a painter great decorative merit, a striving after something less evident than the conventional unity of design we saw in his predecessors, a craving for atmospheric effect yet restrained withal. And as a thinker, one who modernised and adapted the Greek legends to his own use, having one eye on Venus and the other on the Madonna, one on Julian and the other on Savonarola; delicate in thought as though he blushed sometimes to express himself, but not too precious, giving real charm to the onlooker. In the National Gallery and at Glasgow we can easily appreciate the type of Virgin Botticelli had in mind, though none of them contains the essence so much as that of the "Pomegranate" in the Uffizi. But in these, beautiful and fascinating as they are, when you know them well you will feel that the design is too rounded, too melodious, of a too evident harmony of line born often of affectation. In his pagan pictures this is not so evident. The "Mars and Venus" is often criticised for want of classical feeling shown in the incongruity of the theme and the representation, but as line decoration we may here be greatly satisfied. Even if the legs are weakly modelled one can take exception to hardly any other part of the picture on the score of variety and rhythm. It is an excellent companion picture to Piero di Cosimo's "Procris" in the same gallery. But in Florence and especially in the "Primavera," we have Botticelli at his best in every way—in the beautiful atmosphere as if in a May morning, the draperies fluttering in the most delicate way, above all the sense of wonder both in line and expression as essential to all great art in whatever medium as it was extant in the Florence of the day. Botticelli has been dealt with at some length because of the unique embodiment of excellent workmanship and sublety of intellect to be surpassed only by Leonardo himself.

With him may fittingly be compared *Raphael*. The latter leaves the modern racking his brains to find why his reputation till half a century ago was so great. His colour will be found conventional, his design commonplace, his imagination, except in a few of his portraits, non-existent. You may trace most of his tricks in his predecessors; he seems merely to have made logical and therefore uninteresting the practice of men like Perugino, Fra Bartolommeo, and Mantegna. At last the enthusiastic Victorian in search of some merit in his idol will have to take refuge in some such vague and non-artistic quality as "religious feeling." *Michelangelo* is at the opposite extreme. His thought seems always to be above his execution, yet technical difficulties were always his delight. He will be discussed more fully in connection with the sister art of sculpture. But if Raphael's reputation has been blown away, that of *Leonardo da Vinci* (1452–1519) has increased. In his type of womanly beauty, culled though it was from his master, *Verrocchio*, you see the very essence of the Renaissance, and if ever a painter's life was worth writing it was his. In his work you will find a continued curiosity and strangeness, an inquisitiveness about everything, men, flowers, animals, all combined with great mastery of his medium. In some of his drawings in Milan you have, along with Botticelli's charm, far more beauty of line than Raphael ever attained to, and you feel that the painter was no sickly sentimentalist but a great philosopher, as he certainly was. The Louvre is worthy of a long visit to look only at his "Mona Lisa," "St. Anne," and "John the Baptist," and if you will compare them with the surrounding Italian pictures you will find the secret of all good painting, that it results in an impression that never tires. The colour of *Titian*, the faculty of Raphael, the design of *Tintoretto*, all seem of little lasting value before these masterpieces, and it is only when you listen to the still small voice of the Velasquez that you find one who could enter the lists with him. He is the only Italian we should like to live with, who has seen life and commemorated its truth to us. Contemporary with him is *Ghirlandaio* with his frescoes at S. Maria Novella and S. Trinita in Florence, a good all-round man; *Mantegna* of the much spoiled tempera paintings of Hampton Court; *Luca Signorelli*, the forerunner of Michelangelo in heroic anatomy; and *Perugino* and *Fra Bartolommeo*, the masters of Raphael. *Correggio* (1494–1534) is somewhat later. He is the link between Raphael and the Venetians. He keeps for the most part the conventional colours of the former, but allows for the play of light to an unusual extent. His

blues are proverbial, but one misses any touch of the *naïveté* of Botticelli or the strange reason of Leonardo.

With *Andrea del Sarto* (1488–1530) began that decay in painting in Italy which has been stopped only in our own time. He started the ideals of smooth sugary sentimentality and cheap dramaticism without any subtlety of technique. All is mannerism and copy of mannerism, till nothing is left except the aspirations of anæmic young ladies. He is followed by the *Caracci*, *Guido Reni*, *Domenichino*, *Bronzino*, *Salvator Rosa*, *Luca Giordano*, and many even less able workers. It is sufficient to guard the student against them.

When we move to Venice we are in another atmosphere. The Church here has rank only alongside the Republic, and the Republic itself is of less importance than the city itself, the most wonderful of all cities. Among the early painters we may mention *Carpaccio*, with his famous series of the life of S. Ursula in the Academy, and the *Bellinis*, who join themselves to Florence. They at once show the preference of their fellow-citizens for colour over form, and you have only to set a copy of the famous "Madonna" by Giovanni (1427–1516) in the Venice Academy beside a Florentine "Madonna" to see the unconventional design of the former. The "Doge" in the National Gallery is a splendid example of his talent in an unusual form. In the present state of criticism it is impossible to speak of *Giorgione's* work, for every year one hears of pictures being rechristened either in his favour or against him. But such pictures as the "Concert" in the Pitti, the "Antiope and Jupiter" in the Louvre, and the "Fête Champetre" in the National Gallery will have staunch admirers, one would hope, whatever name appears in the catalogue, for their beauty of colour-schemes and execution. They lead us inevitably to *Titian* (1477–1576). In him Venetian art attains its highest power, and he is one of the greatest artists of the world. He accomplished much and in most lines—portraiture, classical and religious subjects, all came within his grasp. At the National Gallery we gain a good idea of his genius in the "Venus and Adonis" and the "Bacchus and Ariadne." We notice the richness, range, and varying shade of his colour, the subordination of line, the quality of his paint, the modelling of the figures, the imagination and truthfulness of characterisation, the beauty and warmth of his flesh colour. His portraits, be it of a Pope or a courtesan, satisfy all ideals; it is only in his larger subject pictures that a modern would prefer, instead of the correct colour arrangements, a more impressionistic handling of the theme, having regard to the effect of light. But he really defies criticism. A modern artist would paint these pictures in a different way, but it is probably true to say that they could not be more pictorially painted, assuming the Titian manner to be right. One may well find faults in the famous "Assumption" at Venice, but Titian's "Mistress" and probably "L'Homme au Gant," or at anyrate the "Portrait of a Young Man" in the Louvre, are without fault. And these are by no means all. The Prado in Madrid has many of his greatest works, and the present writer has a profound admiration for the "Entombment" in the Academy at Venice.

Veronese's "Marriages at Cana" are well known, and his designs are not merely architectural, though very much in the grand manner, and the colour is usually cool. *Tintoretto* is of more importance, but not the world's wonder Ruskin imagined. All the works, however, in the School of S. Rocco, Venice, in spite of the bad lighting conditions, and Anstey's caricatures, repay minute inspection, and with those in the Ducal Palace, especially the "Bacchus and Ariadne," give the student a very complete idea of the painter. His style is easily noticed—the swinging line, dramatic expression, shadows and chiaroscuro. Often little gems of landscape should be noticed. There are two other Venetians one seldom hears about—*Palma Vecchio* of the beautiful S. Catherine in S. Maria Tornosa in Venice, and *Bassano*, whose trick of painting lace and such-like material is copied by Titian. After the death of these men, Venetian art declined till the eighteenth century, when three well-known names appear whom it is well to mention here. *Tiepolo* with his ceilings fails to impress the present writer, though they form excellent material to dance under, and of a piece with the usual Venetian palace furniture, so he cannot speak of them. *Canale*, *Canaletto*, and *Guardi* painted the canals and palaces of their native city. They are well represented in the National Collection, and of the three Guardi gives most pleasure, though why any of them should be the object of a cult, as they are, it is impossible to say. Whistler is said to have considered *Canaletto* the only old master worth looking at.

Spanish Painting.—Florence and Florentine life have been the source of unbounded admiration to travellers for centuries; Venice with its architecture placed in a perfect geographical position has seemed to sum up for most enthusiasts the honeymoon of life; Seville is a city of joy, but its attractions are less evident and less formal. No one building or set of buildings can be picked out as the moving cause of one's love for this southern city—the white or yellow wash of the houses, the donkeys, the patios, the glimpses of gipsy blood, the narrow, winding, irregularly paved streets, the women in their black velas or gorgeously coloured manilla shawls walking seductively down the Sierpes, and the sun blazing over all—all these combine to give Seville a unique atmosphere. So with the painters. Botticelli has his charm, Titian is unequalled, but *Velasquez* of Seville (1599–

1660) gives us the perfect artistic truth. If one might imagine a painter, having imbued himself with all that could be learnt of painting, going to sleep for an age, then suddenly awakening and unconsciously using the old knowledge but trusty to his own vision, we might get an idea of the fully developed Velasquez. In his early pictures, such as the "Surrender of Breda" or "The Topers," both in the Prado at Madrid, you find as accurate modelling, as decorative a use of line harmony, as in his predecessors, but gradually artificial means are put away, and art formed on observation takes its place. If you are looking for beauty of line in his greatest work you will get it. If you seek for gradation of colour no one surpasses him. But added is a unity of atmosphere comparable only to light itself, transferring all into a certain point of view. This makes the position and colour of everything in the picture inevitable; the displacing of the smallest part of it would wreck the picture; and, to attain to the end, the student will notice an inspired use of the paint itself. One feels before his pictures in the Prado a sense of humility raised by the work of no other artist. It is impossible to criticise and difficult to appreciate. One notes certain technical ideals attained, but with no surprise, knowing from the general impression of the whole that every value must be right. It is as if you began to analyse the vowel and consonantal sounds of a great poem. Was this intentional, you ask, this perfect adaptation of means to end, this subtle harmony of sound, one syllable intensifying another, here giving an echo to what has gone before, there contrasting with what follows, and over all a sense of restraint and restfulness in spite of the complexity? The subjects, of course, become unimportant. What does it matter that Philip III was not handsome, that the Infanta is dressed in crinoline? Do you not see the former before you, do you not feel the latter's body inside the stiff clothing? Some have complained that there is no riotous colour, that the tone of the pictures is low. One wonders what is meant. Are the blacks in the "Mœnippus" not rich enough, even if they do not sate? What gorgeous colour could give us such delight as the grandeur of "Las Meninas" with its wonderful sense of space yet so easily taken in by the eye? There is nothing to distract our attention from the general impression, but the surrounding figures are not ignored. Velasquez has viewed the scene with his artist vision and painted it for us for all time. His other great picture, "The Spinners," in the same gallery, appears, perhaps, better in reproduction than the other, owing to a greater accentuation of line motives and marvel of modelling. This is not so evident in the original, and the greater range of colour will appeal to some; but here again there is nothing formal or weak, and the quality of the flesh colour is superb, the whole picture being bathed in that cool, luminous atmosphere that we notice in all his great pictures, including the "Venus."

It is impossible to deal with the other pictures in detail. The Prado gives you all the stages in the painter's art. The landscapes may be noted as delightful works pointing forward to Corot and Whistler; the equestrian portraits are beautiful representations of those horses and riders one admires so much in Spain even to this day; the "Maria Teresa" is a miracle of inspired brushwork, the dwarfs fascinated the painter to excel. But away from Madrid one cannot ignore the earlier work. In the Louvre the "Infanta" claims attention to the detriment of the surrounding pictures, and in the National Gallery the "Admiral," whether by Velasquez or his father-in-law, is a magnificent performance. The "Adoration of the Magi" and the "Jong Philip" there are of his earliest period, the "Christ at the Pillar" is a product of his Italian journey, but also shows the influence of Ribera; the "Old Philip" and the "Venus" alone are works that show the fully developed artist. The former should especially be studied for the quality of the blacks, the latter for the depths of the surrounding space, and both for the brushwork. The "Venus" is unique, in that it shows a wider range of colour than any picture in Madrid. Both pictures show the characteristic of the impressionist period, though they have not the varied fascination of the chief examples at the Prado.

Contemporary with Velasquez is *Ribera*, the realistic portrayer of ascetic Christs and monks, and *El Greco*, the sober colourist who has lately become fashionable. He is not a second Velasquez, but no mean modeller and designer of pictures, as Madrid, Toledo, and Seville testify. Later comes *Murillo*, whose fame has deservedly undergone a cloud. He is chiefly known for his "Assumptions," the finest being seen at the Louvre, and for his "Lamino," both showing marked maudlin sentiment. He has all the faults of the late Italian school with a less wide range of tricks. *Zurburan* connects with Ribera and the early religious work of Velasquez. But it is much later that we find a great artist in *Goya* (1746–1828), one of the finest painters of the eighteenth century. When it suits his mood he can adopt all the graces of Gainsborough or Greuze, but he bathes his pictures in an atmosphere inherited from Velasquez alone. His draughtsmanship is superb, his colour points forward to Manet. And for imagination you may look in vain for anything so wild and penetrating as the etchings in "Los Capriccios," in which he proved himself a keener hitter and as great an artist as Hogarth. He may be studied in the Prado and the Academy of San Ternand, and Seville and the Louvre contain works of the highest quality. The double portrait of "La Maja" at San Fernando is his best,

and at once gives the lie to those who form their conception of the eighteenth century women from Watteau or Greuze or even Gainsborough.

Dutch and Flemish Schools.—While Italy sweetened in sentimental decadence in the seventeenth century, there arose in the north, in Holland and Belgium, painters of a totally different style, both in subject and workmanship. The name of *Rembrandt Van Ryn* (1607–1669) sums up for us all that is manly and virile if not realistic in paint. Dutch art before him had always had a somewhat homely cast, but by his genius he epitomised it for all time. Religious subjects did not appeal to him much, except in his early work, which is finished in the Italian style, but his paintings are full of high intellect. He is essentially a painter of character. He is a sort of Carlyle in paint, not caring for correctness of line or artificial harmonies of draperies, but like Carlyle, a great artist in light and shade. Beautiful nature as such was not necessary for his inspiration, and he did not attempt high colours on a wide range, but he went far in transforming the plain, honest, unsentimental things of this world into an artistically beautiful whole. His work was many-sided. Everyone knows his portraits of old men and old women, studies of wrinkled old age, of people who have experienced many vicissitudes in life. But he is not gloomy, and he is always a painter. He finds matter akin to his point of view in the many portraits of young men in armour or decked for a gala day, in a young woman not of noble but of honest Dutch blood, or again, and perhaps most characteristically, in the great series of portraits of himself. In all he took the subject nearest at hand, and delighted in the subtleties of chiaroscuro, specially revelling in the depths of shade. Of course it is all studio light he sees with; he had not the inner vision of Velasquez enveloping all, as Nature itself does, in a clear atmospheric impression, but one who looked vigorously at things, bringing out the character of his subjects, and making the picture a decorative whole even if to our modern eye it is a conventional brown one. But how more real it is than the contemporary colour schemes of the Italians, and how sound is his modelling and clear his flesh colour. An intellectual artist we may call him. It was not given him to appreciate wholly the beauties of light, but harmonies of shade he made his own. His works are scattered over most galleries, especially in the northern cities, but the portrait of himself and the old men and women in the National Gallery, the collection including the "Man in Armour" and the "Miser" in the Louvre, give us an adequate conception of his powers, while the "Girl in Bed" in the Scots National Gallery with its wonderful modelling and flesh colour shows a greater harmony of colour than almost any other. His landscapes are works of real beauty—his scenes are those of the Dutch farmyard and countryside, but viewed in a way that sometimes leads himself out of his century's brown trance.

Contemporary with Rembrandt are all the Dutch genre painters whom fashion has given such prominence to: *Teniers, Jan Steen, Terburg, De Hoogh, Vermeer of Delft*, and others. They have a charm for us all with their small paintings; here it is stern ugliness, there pathetic domesticity, another time provincial elegance. Again, there are no great subtleties of colour in their purview, but a palette ranging from brown to black, with an occasional flesh-colour or satin dress to enliven things and catch the light. Particularly noticeable are some wonderful examples of still life. All the characters in the paintings are absorbed in the daily doings of the Dutch housewives and their families; beauty is sought in the actions of the men and women, not in their faces, and most have the gift of story-telling—not heroic epic or drama, but good Iambic pentameter. Dull these works are, even if relieved by pleasant surprises, when seen in great numbers as at Amsterdam, Antwerp, Brussels, or the circular room in the Louvre, but no gallery is complete without some examples.

About the same time in Belgium a totally different master had appeared in *Rubens* (1577–1640). If Rembrandt is noteworthy for his intellectual interests, showing Stoic blood, Rubens is an epicurean. Brilliance of costume, abundance of sensuous flesh are his forte, especially the latter and therefore especially the flesh of women. His mythological or historical paintings and even his landscapes are all mere excuses to show off his ideals of women's beauty. Tradition held that in olden times women wore less clothes, so he accepted tradition willingly. By the swing of his drapery he reminds you of Tintoretto, but the subject and mood are changed. His technique is best perhaps in a negative way and the outcome of his interests. He was concerned mostly with women's bodies, and would not degrade them to bare sentimental uses nor even to turbulent dramatic effect. He loved bright colours, but was no slave to Italian harmonies, and especially in his portraits, *e.g.* the "Chapeau de Paille" in the National Gallery and in his "Three Graces" series, the best of which is in Madrid, he is always the North countryman in his sure draughtmanship. He designed an immense number of pictures, but a great part of them were actually completed by his pupils, *e.g.* the famous Medici series in the Louvre. His great defect is an absence of restraint and want of unified impression, but no one outside a Mid-Victorian drawing-room filled with antimacassars should call him gross. Among the great Northern race which has made its name in art, the Flemish, that peculiar people half

Celtic, half Teutonic, one great name appears, *Franz Hals* (d. 1666). His countrymen before him were almost exclusively devoted to religious paintings, whose influence—a bad one—is well marked on many pictures from England to the south of Spain, but with Hals a great advance was made, and we have come to take it now for granted in any gallery we enter and see his name in the catalogue that here at least we shall be inspired, whatever other works real or spurious it may contain. He is among the very few real portrait painters, and thereby with his colleagues Velasquez and Manet marches in the straight line that leads to modern methods. His appeal, like that of all great painters and great artists, is a quiet one, but it is insistent, or rather once it gets there it remains. What, after all, does it matter to us whether a portrait is a photographic replica of the sitter? A few years pass and he is unknown—the picture remains for all time. Thus given a distinct idea, not altogether character, not altogether technique, not altogether colour decoration, but a unity of all—these make the abiding work, the work we long to hang in our rooms, the work we take our best friends to worship before in our public galleries. But if you must analyse Hals' features and are not content with the general statement that he paints the truth, one would mention sureness of modelling, inevitableness of colour values, nothing of minor importance insistent, but a unity of outlook, subtle backgrounds, brilliant brushwork and texture. All these are needed to make these quiet commonplace pictures which one may boldly say shall attract when Titian is felt to be gaudy, Raphael effeminate, and Rembrandt narrow-minded.

Painting in Great Britain.—It is unnecessary in a sketch like this even to mention the early English painters. There are many works in our galleries and private houses of the seventeenth century, signed and unsigned, quite worthy of being put to a critical test, but for our purpose English painting may be said to begin with two foreigners, *Vandyke* and *Lely*. The latter, Sir Peter he became (1617–1680), was a Belgian who early came to England and became the most fashionable painter of his day in this country. The best place to study him is in the National Portrait Gallery, though much is ascribed to him which is the work of his pupils. He formed a rather individual style, not ambitious as to colour effects but with good design and modelling. This cannot be said of *Kneller*, who succeeded him in society's esteem and who is one of the worst colourists of well-known painters. *Sir Anthony Vandyke* (1599–1641), after the usual Italian tour, sought the patronage of Charles I, at first unsuccessfully, but in 1632 he became Court painter and is the most famous holder of that office. He is best known for the characteristic lace ruffles of his sitters and their delicate hands. He was an imitator of Titian in his portrait painting, but does not compare with him in glory of colour and complexity of design. But as a Court painter, working with excellent technique, facile brush, and more than correct taste in draperies, he completely succeeds, and no doubt greatly pleased his sitters, for honours of all kinds were showered on him. The portraits now lent to the National Gallery give a very adequate idea of his talent.

Luckily for English art Kneller's influence, at first very intense, was not permanent, and with *Hogarth* (1697–1764) we make a real start with native art. And it is refreshing in this eighteenth century, so prosaic in other mediums, to find works worthy of admiration. Hogarth is a child of the century in his anecdotal power, which is no greater nor deeper than that of Pope, but his technical ability is beyond that of the Georgian school. Perhaps the "Marriage à la Mode" series in the National Gallery shows him at his best. His colour and design are not of the highest, but one has only to compare him with Kneller to appreciate his efficient pictorial qualities. Contemporary with him lived *Joshua Reynolds*. Hogarth prided himself on his anti-foreign connection. Reynolds is a sort of Tennyson who has known and appreciated all the beauties, and it may be added the tricks, of the old masters; so much so, indeed, that his great fault is that his work is too professional. He lacked the quality of spontaneous genius which is above training and even knowledge. But for completeness, for variety of accomplishment and sound technical knowledge, he quite deserves the traditional place he holds in English art. It is only in the later nineteenth century that his ideals are seen to be too inelastic. His great rival, *Gainsborough*, was of a different mould. He was no leader of society and intellect; he contented himself with looking on the beauties of English scenery and womenkind and interpreting them in his own way. And with no mean result. His colour and brushwork have greater qualities than those of Reynolds, and his pictorial sense very often places him among the greatest painters of the world. Unfortunately, neither Reynolds nor Gainsborough is seen to the best advantage in our public galleries, for their finest work is scattered over the country in private collections. In the public mind along with these two *Romney* is associated, but it must be admitted that his gifts are of a lower order and a great part of his popularity is due to the prettiness of his sitters, though here again public galleries do not do him justice, for he frequently shows fine ability in design, especially in drapery. Alongside of these men there lived *Richard Wilson*, whose landscapes at their best have great charm and delightful pictorial qualities, though too often marred by pseudo-classicism. Scotland at the time had a painter in *Alan Ramsay*, who is too little known, for his best

work—he was very uneven—is in a manner not learnt from any master. The portrait of his wife in the Edinburgh collection shows very delicate handling, wanting in sureness no doubt, but pleasing in a marked degree.

Passing over Hoppner owing to the inaccessibility of his work, we come to *Raeburn* (1756–1822), the famous Scottish painter. His reputation has of late years been rather clouded among artistic circles, but no one who has studied such works as the "Colonel Macdonnell of Glengarry" (Edinburgh), the "Sinclair of Ulbster" (Glasgow), and the "N. Spens" (Edinburgh) can fail to say that from a modern point of view Raeburn was a most interesting if not exciting artist. As a colourist he sometimes achieves the highest things, though his shadows usually ignore local colour with its difficulties, otherwise his values are extremely good; but his simplicity of brushwork, satisfactoriness of design, his sense of atmosphere and, if you like such things, his characterisation, move us to admiration. His reputation but not his good qualities descended on *Sir J. W. Gordon*, one of the first of these respectable portrait painters one meets every year at the Royal Academy, but in this case the English president was far above his Scots colleague, for *Lawrence* (1769–1830) with many imitated vices was a man of much greater ability. The Augerstein portrait in the National Gallery and under half a dozen in the Portrait Gallery are well worthy of study. Those who like so-called history represented in canvas as a rest from the ecstasy of artistic ideals will find *J. S. Copley* and *Benjamin West* least puerile, but it is folly to waste time on these when we may look at the work of three personal artists of the day: *Crome*, *Turner*, and *Constable*. These three men stand at the parting of the ways. They have one foot on traditional soil, the other is raised to go forward into the sun.

Crome (1769–1821), or "Old Crome" as he is called, shows a delightful personality in his work, analogous perhaps to Crabbe in poetry. He profited much from Hobbema and others, but he is English of the English, and in such pictures as "Mousehold Heath" in the National Gallery, and the "Landscape" in the Tait Gallery, he shows himself as no mere topographical student, but one who had a shrewd eye for the truth. *Turner*, slightly later in date, is a mighty figure wrapped up in his art, seeing visions and communicating them to us as best he may. To him, nature is no slave, but a lover whose beauty it is his proud mission to show to the world. He has left to the care of the national collections hundreds of oil paintings, water colours, and drawings, so that no one need be ignorant of his worth. It is rather staggering to the untutored eye, even if he has read Ruskin. He will find a complete change from the Italians and even from Velásquez. But presume for a moment that the riot has some reason in it, allow yourself to be caught up by the artist into his heaven, and untold delight will result even if it is accompanied by a little shame at the orgy. The defects are of course obvious. A Titan cannot in the nature of things be an artist, though he may breed them. His view is not often the truth of the impressionist—a scene which the eye takes in at a glance; restraint is wanting and a unifying harmony. Some of the pictures are like the full blast of the brasses of an orchestra, not the music of a symphony. It is magnificent, but it is not the highest art. Some well worthy of attention in the National Gallery are the "Fighting Téméraire," "Ulysses deriding Polyphemus," "The Brook," "A Frosty Morning." His etchings and drawings are unfortunately outside the scope of this sketch. Turner left no followers. *J. Constable* (1776–1837) has influenced directly or indirectly every landscape painter after him, for the French movement viewed his works exhibited in 1824 with open eyes, and Corot and his contemporaries followed. Like every true artist he knew that what exists in nature is of less importance to the artist than what is seen, that selection must always be made. His tone is exquisite; no one before him represents the freshness of English scenery with so much beauty. The sense of space, the sombreness of shadow (sometimes too black), and withal his design is never commonplace. He made the great discovery, undreamt by his predecessors, that the world was not of a uniform or graded brown tinge; to do that he had to go out bravely into the open air, feel the strength of the wind about him, smell the flowers and shrubs, and listen to the sound of running water. But hero that he was, he braved the hidden dragons of tradition and took his paint-brush along with him; with the result, of course, that painting came to its own—no longer was it an exercise of the study, an imitation of old masters' recipes; and wonderful genius that he was, he did not jump to the other end of things, but escaped the botanical craze of detailed classification and painted what his eye saw. All this and more you will recognise in the wonderful "Cornfield" in the National Gallery, the "Haywain" and the "Vallery Farm" and the exquisite pictures and sketches in the Victoria and Albert Museum. It was, however, the followers of Old Crome who attracted most attention—the Norwich school, of whom the greatest was *J. S. Cotman* (1787–1842), but he is most admired for his water colours and drawings.

We have made no mention of some later eighteenth-century men. *Morland* (1763–1805) deserves close study. His pictures of inns and other typically English spots with their stables and horses (there is a good stable in the National Gallery and another in the Victoria and Albert Museum) are apt to be overlooked by the busy visitors, but his technique on nearest sight will

be found admirable and unique among his kind. *Etty* (1787–1849) when at his best is also too much ignored, but no one interested in flesh colour will pass his pictures by. *Landseer* needs no introduction, and the present writer is unable to praise him, but *Wilkie's* fame is founded on surer talent. In the National Galleries of London and Edinburgh alike you will find work to interest you quite apart from their anecdotal value, and if you *do* happen to visit the latter capital, the Scotsman *Philip* will not at all remind you of the Velasquez you have worshipped in the Prado and with whom his contemporaries named him, but nevertheless he may captivate you not a little by his colour. These and their colleagues for the most part had a necessary minimum of good workmanship, and as their aims were not primarily artistic, it is perhaps fairer to ignore them than to test them too critically. With them we leave for a time the eighteenth-century art of our country, not unsatisfied. If we think of the dull literature of the day—the great prose age—we find as a whole a much higher achievement in painting than in poetry. Turner may vie with Blake, but we have still Constable soaring aloft. The stars of Reynolds, Gainsborough, and Raeburn blaze far more brightly than those of Pope, Dryden, and Gray; their intellects are not inferior and their workmanship is far above that of their friends. And if we turn to other countries, we still find cause for national pride.

Painting in France.—French painting starts with the two Italian-inclined men, *Nicholas Poussin* (1594–1665) and *Claude Lorraine* (1600–1682). These two were the introducers of that extraordinary representation of landscapes as consisting of studio-coloured trees, Roman ruins, with a few seventeenth-century nymphs thrown in just to enliven things up. They influenced French and British art till the day of Turner and Constable, and gave the world that idea of French correctness which the present European war will at last destroy. In the eighteenth century, Voltaire, Diderot, and Rousseau did achieve this, but they reached high literary standards. When we look at the painters we are still more disappointed. Yet the artists of the day thought that they were making a revolutionary change when they transferred to the leadership of Watteau from that of Poussin. The twentieth-century critic cannot find much real change. *Watteau* and the others transformed the habitation of the gods from spurious Elysian fields to elegant courtly groves, but to call these "fêtes champêtres" and "petites waisons" a return to nature is something the present writer cannot understand. Go to the Wallace Collection, or the Louvre, and analyse your sensations. True, these pictures represent the conventional idea of the French courts, but are they any the better for so doing? The colours are bright, and in Watteau's case the brushwork good, the design not strictly Italian, but if one is therefore impelled to call them decorative, let him pause and think, say, of the post-impressionists of to-day and he will at once see how feeble the sense of decoration dwelt in Watteau, *Boucher*, Pater and the rest. He will surely murmur, "If this is nature, then let us pray for convention." If we think there is beauty in Watteau, let us remind ourselves of Leonardo, Velasquez, and Hals. Or again, how inferior they are to the Venetians they imitated, There is as little subtlety in their combination of the colours as there is in their thought, and if in one or two men's faces a trace of character has crept in, the women are all of the same type with small features and piquante faces. And Boucher with his eternal blues and roses is even less complete and must be put in the same category. Contemporary with these two was *Chardin*, but of a very different nature. Again there is no subtlety of technique—he paints the lower classes as he finds them, but there is little genius in his observation, or at any rate in his representation of it on canvas. *Fragonard* has touches of Chardin and Boucher both in his work, giving puttiness to what is called lower life. And *Greuze* is known to all, at one stage of our life—Greuze with his attempt at stern morality and his success in showing sentimental women and children with often pasty faces not differing much in texture from the surrounding clothing. Rousseau had arrived and his readers were bathed in tears. This, then, was an antidote to classical legend, for the Greeks knew no sentimentalism. The works of all these men at their best may be seen at the Louvre and in a small way in the Wallace Collection, while Scotsmen have some wonderfully good paintings by Watteau, Boucher, and Greuze in their National Gallery. If one is satisfied with this traditional idea of France there is no more to be said. But even if true—and we recalling Pascal, Voltaire, and the French Revolution cannot so regard it—it must always be remembered that representation is only a small part of art. The brute is evident to us all; it is the artist's *métier* to uplift the brute to meet its God, as Meredith has said. These men, no doubt, were all gifted, but talent is not genius. The true French spirit is far better typified in the work of *Degas* and his brethren. They had, as we shall see, the piercing eye which is the foundation of art—that and the master-hand to show their sight to the world. Watteau and the others may have seen such men and women around them, but their art, in spite of its bright colour, would in that case be little better than photography, with a moral attached.

They were succeeded by still one more outburst of quasi-classicism about 1760. This return to Greek ideals was housed at Versailles, and all went happily as a marriage bell until the inevitable crash. Watteau and Boucher

were dethroned—it is said that David's pupils shot breadcrumbs at their pictures—and *Madame Vigée Le Brun*, whose paintings you meet in the Louvre as friends of your youth, reigned as Aspasia. But *David* was the first spokesman of these Romans, and it must be admitted that if there is no trace of the Elgin Marbles in his work or of the real ideals which inspired Pheidias or Sophocles, yet as far as the generation knew its Rome he sternly tried to venerate it both in his life and his painting. He was great neither in colour nor in line, but as the originator of the archæological picture in France and England he must, one supposes, have some place in our thoughts. His best-known work is the "Madame Récamier" in the Louvre, but his portraits of men are more worthy of attention. Following him, colour is banished from the apex of art and classical noses and correct draperies for the criteria of painting. But he had not everything his own way, for *Prudhon* combined a love for Leonardo with that for many women (as who does not?), and succeeded often as a minor Correggio and in some drawings. His life was gentle, and therefore apart from his work he is worthy of mention. But soon we come to *Ingres*, less of the "Source" than the portraits and sketches, the not altogether faultless drawer and the not altogether cold classic that his fight with the Romantics would make us believe; and certainly not the originator of the Royal Academy nude. Not then so wicked as usually reputed, but unfortunately on the wrong side, for the Romantics had arisen and France at last was to be free from the artificial aspiration to a dead and half-known ideal. It is quite unnecessary to relate the tale of the Revival. Rousseau, Goethe, Thomson, Scott, Wordsworth all had their share; Constable was the immediate cause. About 1830 a school arose in France with the warrior Delacroix at its head, which, reinforced by all the great names in literature of the day—Gauthier, Victor Hugo, Sainte-Beuve, Baudelaire—set forth in a new battle of the books. Many a hard knock and word did either side receive and give, but the victory lay with the Realists and Romantics, though, of course, the French Salon like our own Academy carried on the routed tradition. On the other side we get the great names, especially in landscape, of *Rousseau, Diaz, Millet,* and *Corot,* which, combined as they now are with the impressionists —for Corot united the two and the newer men pay homage to their elder brethren—stand for all that is best in modern French painting. And in dealing with them we may ignore *Bouguereau, Lefèbvre,* and even *Meissonier,* as well as many others less well known. Probably no school is more companionlike to the layman who wishes to understand pianting. These men of 1830 are not supreme artists, nor technicians; one of them may be a realist, another a poet—both non-artistic qualities—all have a very sound standard of workmanship.

He who would understand Wagner will find Mendelssohn *intime* to begin with, provided he has a good ear; the embryo lover of Shelley will first appreciate Tennyson. This is not to say that Corot was as commonplace as Tennyson nor so merely facile as Mendelssohn, but it has to be owned that so ingrained in our minds is the photographic point of view with its acceptance of traditional "browns" as the most prominent colour in nature that the truth of twentieth-century sight which is the monopoly of the artist, the child, and the savage comes but slowly and gradually. It must be remembered that, for example, the art of playing football is not recognisable in a moment, yet most people seem to think that the man in the street has an artistic vision quite sufficient to criticise any picture put before him; and if one ventures to question it, the delphic utterance of "I know what I like" is deemed to cover unplumbed depths of stupidity. The chiefs of this *Barbizon School*, as it is called from the little village to the north of Fontainebleau where they lived, are *Corot, Rousseau, Dupré,* and *Diaz,* and the forest was their inspiration—the forest and the light of the sun. *Rousseau* was the first in time and he bore the brunt of the opposition. He saw Nature as a thing to be studied minutely and reverenced, then having knowledge he could express his mood, but always through Nature. He is essentially a lover of form, especially as contrasted with Corot. A thoroughgoing Impressionist would call him meticulous—he seems to love every leaf of the trees—but he is no English Pre-Raphaelite. He is of the true line of landscape-painters, and one who perhaps did as much as anyone to show Nature in its native colours. It is open-air work, not dramatic, not really poetical, without the inspiration of Monet's colour, but real without being merely representative, rather cold and plain perhaps, sometimes a little prosy, but with catholic taste and always with great workmanlike qualities. *Corot* is quite different. All visitors to modern galleries have learnt to recognise the cool, shimmering silver of this poet of Fontainebleau. It was late in life that he came to his own and abandoned classical futilities, but not too late, for he ever retained the joyous soul of a boy. And his cheerful temperament is abundantly seen in his work. But it is in no sense sentimental if lyrical. He is a greater colourist than Rousseau, though he limited his range so much and confined himself to aspects of early morning and later evening—a personal choice in keeping with a disposition that neither knew nor cared for any violence or drama or crude effect. The figures in his landscapes, the remnant of his earlier devotion, seem out of place, for drawing was not his forte, but they never spoil the delicate beauty of the whole.

The realm of painting is the poorer if it excludes the point of view of such a man, founded as it was on love of the brute elements. His is a gentle theme, quiet and orderly, but full of beauty. Dupré, again, is the dramatist of the group, the lover of storm and thus of Nature—of the wind and the water, and therefore a colourist, an enthusiast indeed, even a fanatic, but all for art's sake. *Diaz*, who combined a voluptuous love of the inmost recesses of the forest with popular nymph-painting, thus became the wealthiest painter of the day. Of the others more or less of this school it is sufficient to name *Daubigny* of the picturesque country scenes, *Troyon* whose animals are not the only satisfying parts of his pictures, and *Charles Jacque* whose etchings and paintings of sheep and farm buildings have excellent qualities. The works of all of them may be studied best at the Louvre, but most galleries have good examples of Corot, Diaz, and Rousseau, and their pictures are wonderfully equal in merit. The National Gallery is very representative, owing to some recent bequests.

Impressionism.—Our glance at the work of Velasquez has forestalled, as is only right, any detailed examination of the theory of Impressionism. Its essence, we have seen, is the painting of the natural fact as seen, subordinating and transforming all the parts of the picture to one impression under the influence of light. We have noted how the Barbizon school began the study as applied to landscape; we have now to observe how its results affected even studio pictures. The giant figure with whom the movement is associated is *Edouard Manet*, who appeared before the public in a new guise in 1862, and with the well-known pictures "Déjeûner sur L'Herbe" (now in the Musée des Arts Decoratifs in Paris), "Olympe" (Louvre), and other pictures raised a storm of indignation against him and his colleagues in succeeding years that did not subside till after his death. The two pictures mentioned must not be cono fused with examples of Impressionism—they are not so. Both were disliked far more for their subjects than their technique, and it is wholly with the latter that Impressionism is strictly concerned, though it has certain other results. They are merely bold experiments in harmonies of colours, unadulterated by any so-called romantic gloss, but not as yet showing the influence of light, and Goya, if anybody, is his master. It was not till about 1870 and when joined by *Degas* and *Monet* that his full powers are to be seen. Then there followed such beautiful canvases as "The Fight of the 'Kearsage' and the 'Alabama,'" "The Bar at the Folies-Bergères," "Jeanne," "A Garden," "Bal de l'opera," "Le Bon Book." He died in 1883 when the movement was just beginning to be taken seriously. It is most unfortunate that his best works are all in private collections and only occasionally gathered together for exhibition. The Caillebotte collection in the Luxembourg gives no idea of the versatility nor profundity of this master by whose influence modern art has been created. The Dublin Gallery is much better, but the visitor to Paris should always make a point of visiting the galleries of M. Durand Rull, a dealer who has done more perhaps than anyone else to encourage the work and bring about a just appreciation of the Impressionists. One frequently in odd places meets some of his early work—Mr. Cowan of Edinburgh has a beautiful deck-scene painted when the artist was yet a sailor—all show the curious eye seeking unusual effects. No painter is less commonplace. The man in the street will scoff at the harmonies just as he did with Wagner; the student will find all his work of supreme interest, and they are all pictures to live with. They set up a wholly individual point of view, subtle and therefore requiring some patience before it is grasped. When it has been reached one goes through the pleasurable experience of seeing all things in the colour of Manet. His great contemporaries are *Degas* and *Monet*. The former, who still lives in Paris, is as stern a lover of his art as any artist the world has ever seen. In spite of malign opposition, in spite of a bravely satiric vein of his own, he has never ventured into the fray; he has painted for the thing's sake, and if people do not appreciate, then that is their fault. Unfortunately, too, if they do seek to appreciate they meet with no warmer greeting; and the present writer has a very clear recollection of how he was received when, filled with youthful enthusiasm, he ventured to approach the master. His best-known works are of ballet girls in group or by themselves, and his unique vision has vested these stiff white figures at rest or in motion with a beauty no painter of the Madonna has ever achieved. Influenced by two directly opposite tendencies, the composition and colour of the Japanese and the draughtsmanship of Ingres, he has combined both with extraordinary effect; and no one has ever shown the wonder of artificial light as he, and the harmonies he produces in a combination of black and white put a Venetian to shame. He has also painted many pictures of race-meetings, nudes (especially while bathing), café scenes and landscapes, while in a pastel of his own he is a master. He is better served than Manet in the Caillebotte collection, and there is a good example of his work in—of all places—the Victoria and Albert Museum; but, the painter's own studio being as suggested inviolate, few opportunities are given of seeing his work, and as usual with these painters they do not allow their works to be photographed, so that few people have even a passing idea of what it is like.

If Manet was the man who bore the brunt of the battle, if Degas is the greatest artist of

the group, *Claude Monet* is the painter who has most revolutionised technique, for it is largely due to him that the theory of broken colour or chromatism has been applied. In every gallery nowadays one notices these pictures, which have to be looked at from some distance. If looked at near at hand, they will show a mere conglomeration of colour spots; at the proper distance, the division of tones, the complementary colours unite and reconstitute the colour, broken up as it has been into its component parts, and the effect is far richer than the detailed and minute finish of the Pre-Raphaelites or Academicians, for the impression formed on the visitor by this means is exactly what the painter had in his own eye and has communicated to us by his brush. Monet's pictures are all poems in praise of the sunshine—at its brightest when there are no shadows in the scene, dazzling to the eye; at other times with wonderful shade, with no hint of black. It follows from this that he and his followers cared nothing for historical or literary ideas in a picture. They painted the earth, selected its beauties—hayricks, riversides, trees—and the result is matter for worship. The term Impressionist arose from the name given to one of Monet's pictures, and at first given in derision it was enthusiastically adopted as a true badge by his followers, and it has been shown here to be the keynote of all art. In his work we have not to flit our eye from one side of the picture to another; we do not retire to the botanical laboratory and count the number of petals in a flower—we stand at once before the rich fertility of Normandy with its gorgeous colour. We need no moral, no legend, no literary touch of any sort; here is a reading of earth—pagan as it used to be called, certainly truly classical as if Pan were still abroad. But why the god of the twentieth century should be dissociated from nature in its most beautiful guise it is difficult to see. Yet there has always been an idea abroad that the Impressionists were rather immoral—the only reason being that not being in the pulpit they forgot to preach. *Renoir*, again, is totally different. He exercises himself with the Paris that all visitors wish to see—scenes of all kinds in the open streets, inside cafés and theatres—everything is as "natural" as one could imagine, but everything is responsive to the artist's purpose. He is perhaps chiefly concerned with the flesh of his subjects and the effect of light upon it, but he has many moods, and his glorious colour values, his cleverness, his gay manner—a Frenchman he is if ever there was one in intellect and execution—all appear whether in landscapes, nudes, or portraits, and make him probably the most thoroughgoing representative of the group. In addition to these immortals, we have *Sisley*, *Pissarro*, and the *Pointillists*. *Sisley* is a most poetical artist. *Pissarro* adopted the technique of the *Dotists*. Where other Impressionists were content to indicate complementary colours in splashes of colour according to need, the Neo-Impressionists, or Pointillists as they are appropriately called, have made the theory of broken colour into a science of dots of equal sizes with rather a mechanical and disturbing effect. Seen at a distance, however, the colour of a good artist in this medium is extraordinarily rich in effect, which, of course, is the result desired. This departure has had its inevitable reaction in the *Post-Impressionist* school, which by a totally different route seems to reach the same goal. It is mentioned here in connection with English present-day painting, though Paris is its domicile.

An artist whose name has been omitted because he is of no definite school is *Boudin*, and he is one of the most beautiful painters France has given birth to for many years. It is most unfortunate that the few pictures he did sell have been scattered so widely in private collections and that few of the famous galleries have examples of his work. Luckily our own National Gallery has two very beautiful seascapes. His painting breathes of the sea and coast he so intimately saw. He was not exactly an Impressionist of the broken-colour school, but otherwise he unwittingly subscribes to all their ideals. For richness of colour, adequacy of values, truth of impression and gaiety of atmosphere he is with hardly an equal in his best work. He lived and died unhonoured.

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A note must be made of the *nineteenth-century Dutch painters*. After the seventeenth century, art in Holland deteriorated and became more degenerate in the succeeding century, but with modern days Holland has again lifted her head among the artistic nations. *Joseph Israels*, *Jacob* and *Matthew Maris*, and *Anton Mauve* may be taken as representative of a group of artists whose work is a source of continual delight. It is not altogether a native effusion, for it owes much of its inspiration to France and England, but it has given as much influence as it took. *Israels* painted popular subjects, with strong sentiment but sound draughtsmanship. His domestic studies, if they bring tears to the layman, bring joy to the artist, for his cleverness in draughtsmanship and atmospheric effect is remarkable. *Matthew Maris* has as delicate a touch as a vision. But he is far removed from "preciousness," sound workmanship showing in all his paintings. His brother *Jacob* has brought the art of selection to a high point. He simplifies the world around him to a very exquisite harmony. *Anton Mauve's* pictures delight us at every turn. Again there is a beautiful atmospheric effect, a delicate vision, exquisite workmanship and simplicity based on cleverness. Others who might have been mentioned are *Bosboom*, *Neuhuys*, *Mesdag*—all real little masters of this charming group. The

interiors of Dutch houses, peasants, canals and the sea all come under their purview, and they delight us all with their imaginative representation.

Present-day Painting in Britain.—Before discussing the great movements in the nineteenth century, a note must be made of one of its chief painters who held aloof from all of them, *George Frederick Watts*. Trained in no particular school, he confined himself to two great branches, allegory and portraiture. The former are his best known, and few galleries are without some example. It is true that they make their appeal for the most part to people who patronise art because of an acquaintance with literature, but mythological as their titles may be, the essence of their mission is easily understood by the multitude. That mission was a typically nineteenth-century one, refined, intellectual, but rather dull—Tennysonian indeed, and their technique of a similar kind. His portraits, large collections of which are in the Tate and National Portrait Galleries, always show strong character drawing, some of his heads being specially well modelled.

The movement with which Mid-Victorian life in England chiefly concerned itself was that of the *Pre-Raphaelite Brotherhood*. It was of a piece with the Gothic Revival in architecture and shared with it the praises of the dictator, Ruskin. Certainly British painting in 1848 had reached a very low level, and something —whether right or wrong—was needed to instil life into its dry bones. Much has been written and refuted about its aims, but to a modern eye there is one bond of connection between all the members of the society, viz. that they endeavoured to go to what they called Nature, to get behind conventional representations of the world and come down to earth. Too much need not be made of the name they adopted, though one of the outcomes of the movement was a general and uncritical eagerness to possess early Italian works. Their method of working out their salvation was scientific—minute detail being of supreme importance. *Dante Gabriel Rossetti*, the poet, was the ruling spirit, and attempted to carry out in his pictures what he most successfully did in his poetry. He had not, however, the necessary painter's equipment, and in any case he seems to have confused the ends of these two differing arts. What is thought and imagined cannot be described in the same way as what is seen. His best work includes "Lileth," "Beata Beatrix," and the "Beloved," and are chiefly noticeable for a certain sensuous langour in the women painted and a remarkable disregard to lay out the qualities of the medium he worked in. *Ford Madox Brown* is the chief story-teller of the company, but he again was unaware of the limitations of his art, the power of pure paint restrained by a decorative master. *Burne-Jones* did greater things. He had a fine appreciation of colour and would have been a great designer of stained glass if he had paid more attention to glazing. In his pictures he shows similar defects to those noted in the case of Rossetti, but there is reason to suppose that with a different training his technical equipment would have been greatly developed. "King Cophetua" in the Tate Gallery, "The Depths of the Sea," and "Laus Veneris" are among his best paintings. *Holman Hunt's* religious paintings are well known and much discussed for non-artistic reasons. *Sir John Everett Millais* by his subject pictures and portraits attained to the highest honours before his death. He was a fine colourist and an obedient maker of likenesses, but in a number of his paintings excellent decorative effects are achieved. The Tate Gallery and Royal Academy give a fair idea of his talent, though the "Eve of St. Agnes" is in a private collection. The movement has had many followers, though they are now less common than twenty years ago.

Strictly opposed to the Pre-Raphaelites, if not in theory (for both aimed at reality) at least in practice, are the *English* Impressionists—the members of the Glasgow School. Of these we may be justly proud, for they have shown that at home we can lay claim to as great artistic fame as any other country in Europe. The influence of Manet and his followers inaugurated the movement, but one has only to look at the many Scotch pictures in continental galleries to recognise that the Glasgow men were anything but imitators of the French. It is most unfortunate that their work is so widely scattered, but in any exhibition the catalogue should be scanned for their names. Chief among them are *Sir James Guthrie*, President of the Scottish Academy, *J. Lavery, G. Henry, E. Hornell, J. Paterson, E. A. Walton, I. Austin Brown, Joseph Cranhall, W. Y. Macgregor, D. Y. Cameron.* Guthrie's portraits are masterpieces and show him in line with the greatest painters. His draughtmanship, colour, and brushwork are all of the highest quality and his decorative schemes of unerring beauty. And succeeding years show no lack of power, as witness his "Sir William Turner" in the Academy of this year (1914). Always there is the same masterly handling. His landscapes, as shown by the "Midsummer" in the Scottish diploma collection, fulfil the true Impressionist ideal. If Guthrie is complete, *Lavery* is exquisite, and no living painter probably shows greater genius in his work. Paris, Venice, and other continental towns have secured examples of his work, but Glasgow's "R. B. Cunningham Graham" is a picture any gallery or any painter might be proud of, and if one is reminded of Velasquez, both the sitter and artist have reason on their side. Like many Impressionist painters, Lavery has been influenced by Japan in his decoration. The exhibition of this year of a representative

series of his work in London showed him a many-sided if unequal genius. He has even become a fashionable woman's painter, but he seems more at home painting sunlight on a beach or sketches of Pavlova. Lately he has given us beautiful Swiss nature-studies, one of which the Edinburgh Gallery has been shrewd enough to purchase. Another great name is that of *George Henry*, but in spite of the fact that he is now an Academician his work is too little known. It is of exquisite merit, and both in portraiture and figure painting he excels. True decorative beauty governs all his work, for he is a designer *par excellence*, and joins hands with Lavery in showing forth the joyousness of human life. *Hornel's* thickly-painted, richly-coloured Japanese-like children appearing out of and as part of some gorgeously lit vegetation appeal to us all, even if we sometimes crave for a somewhat different subject. But really we cannot have enough of such brilliance of colour effects. *James Paterson* is perhaps the most individual artist of the group. His landscapes fulfil all pictorial conditions to a high degree, but over and above that he interfuses all with a sensitive poetical atmosphere. He thus, as few men have, represents the inner reality of a scene, with no false sentimentalism and no outside literary appendage, but by the beauty of his own vision and a delicate appreciation of the subtle colour harmonies of the natural world. His water-colours are of supreme distinction. Needless to say, his work has been sought after on the Continent as well as at home. It is interesting to note in passing that his son, H. C. Paterson, is gaining a name among the younger Edinburgh artists as a painter of undoubted talent. *Walton* is the fourth of the Glasgow portrait painters who are thus shown to have an extraordinary wealth of ability, for it must be remembered that little as is the mention made of these and the remainder of the group, any one of them by himself would lift his native country from obscurity to artistic fame. Walton has the same varied powers as Guthrie. Whether he paints some academic notable crudely clothed, a little girl, or an imaginative water-colour, he succeeds in all in obtaining justness of drawing, tone, and atmosphere. A collection of the work of the late *Joseph Crawhall* in this year's Scottish Academy showed to a wider public the genius of this great painter of animals and animal life. One has only to compare him with Landseer to appreciate what Impressionism has done for art. Here, what is seen is depicted, but with no want of selection. The unessential is ignored and beauty of pictorial representation is achieved. Whether it is a fowl or a gorgeous Spanish bull-fight that is the subject, over all the artist's touch reigns. *D. Y. Cameron's* fame rests mainly and surely on his genius as an etcher, but as a painter he every year adds something of high merit. He has painted portraits and figure studies, but of late years most of his compositions have dealt with mountain scenery. Coupled with an exquisite observation of nature, natural to an etcher, he within a small compass of tones creates broadly-handled effects of great dignity and beauty. *W. Y. Macgregor* as a colourist has few peers among landscape painters, and seems to come nearer his French colleagues than the other Scotsmen. He always shows clear thinking in his schemes and a consequent sureness of touch that give the appreciative onlooker untold delight. Other painters of this movement all producing remarkably able work are *Alexander Roche, George Pirie, Whitelaw Hamilton, Harrington Mann,* and *Macaulay Stevenson,* the imaginative landscapes of the last named being far too seldom seen, although the Glasgow Gallery has a beautiful specimen of his art.

Two men who cannot be classed as Impressionists greatly influenced the Glasgow School, *J. M. Whistler* and *W. McTaggart*. The former, who in nationality prided himself on being an American gentleman, spent so much of his life in London that he must here have notice. In many ways he was the greatest artist of the century. Influenced at first by the French, but relying on an extraordinary and peculiar individuality of his own, he created a style of his own that reminds me now of Manet, now of Japan, now of Velasquez. But even then a lot has been missed out. He worked in most mediums, his etchings and lithographs and decorations being especially sought after, though as an etcher he has not quite the same fame as during his life. His "Nocturnes," wonderfully imaginative compositions, usually of low tone but extreme delicacy, gave rise to heated discussions, including a famous libel action. Since then critics have been led by the hand to the Thames at night and admitted the reality of Whistler's vision. His best-known works are the portraits of Carlyle (Glasgow Gallery), Mrs. Whistler (Luxembourg), and Miss Alexander (Mr. Alexander). The appeal of the first two is irresistible to everyone, both in the quiet insistence of the design and the inevitableness of the draughtsmanship. But unfortunately the third is still in the hands of a private person, though he has been generous in lending it to several exhibitions of the master's work. One can think of no more beautiful picture to characterise all that is best in late nineteenth-century art. Here is art for art's sake become beautiful and true, and no more is wanted. The warmths of the black and white harmonies, the human element of the little girl not too conscious but unafraid, the charmingly intricate folds of the dress, the quality of the paint in its representation of dress-stuff and hair, the value of the black shoes and hair-ribbon, the beautiful spacing of the figure—everything even to the much-

thought-out signature of the artist make for the delight of the eye and the satisfaction of the mind. His other portraits are numerous, but all remain secluded in private collections, and Whistler was never an Academician. The other artist we have mentioned, *W. McTaggart*, seems to have discovered Impressionism by himself. Most of his paintings represent scenes by the seaside, often with delightful glimpses of children on the beach. They are masterpieces of their kind, showing great study of colour effects and genius in representing what was seen. He exerted, as has been said, a very great influence on his Glasgow colleagues, who could not but recognise in him one of the greatest painters Scotland has produced. Even his sketches are worth going miles to see, and he was not over-appreciated by the lay public in his lifetime.

Another Scotsman who became deservedly famous in his short life was the Aberdonian, *Robert Brough*. Though not of the Glasgow School he shared many of the ideals of the French Impressionists, and his work though unequal is very often so clever as to amount to genius. At his death at the early age of thirty-two he was one of the most fashionable painters of women in London, but here fashion had somehow gone on right lines. The Tate Gallery has his "Fantasie en Folie," the Edinburgh collection a beautiful portrait, and Venice two of his works, but again for the most part municipal collections have ignored him.

To return to England, mention must be made of those who have not to any great degree deviated from the straight path of academic tradition. Best known are the archæologists or false-delineators of antique life. Chief among these have been *Lord Leighton*, *Sir Alma Tadema*, and *Sir Edward Poynter*, to name whom is to show how popular such work is, so that nothing more need be said of them. Of one, the late *Albert Moore*, it must be owned that he was an artist in spite of his supposed love for antiquity of the picture-palace style. Both in composition and from a decorative point of view his works are of great merit, and he did not deem it necessary to overload his themes with the curious expressions of Greek sentimentality discovered by these antiquarians. An attempt to form a school was made some years ago by *Stanhope Forbes* and his wife, with no little success. These Newlyn painters, while really in tradition of J. F. Millet or perhaps Joseph Israels, have added an English note in their representations of fisher life. If not exciting, their technique is quite workmanlike. It is quite unnecessary here to mention the many popular Academy favourites. These will be sifted by those who take the trouble to appreciate what has been written about their more able brothers. It is quite wrong, of course, to suggest that all popular painters are bad workmen—for one thing, they have very often quite remarkable photographic if inartistic powers.

It is sufficient for our purpose to mention a few who have individualities of their own. Of the older men, two lived short but important lives. *C. G. Lawson* showed promise of combining the best of what had previously appeared in English landscape painters with a point of view all his own. One of his best is to be seen in the Tate Gallery. There, too, one may mark the great talent of *C. W. Furse*, who also met an early death. His "Diana of the Uplands," in spite of being reproduced so often, is a very notable work. Still with us, however, is *Mr. Mark Fisher*, whose distinguished landscapes pat our national pride on the back when we meet with them in a gallery. He is more in line with Constable than with the Impressionists, but has something of the latter's brilliance of colour effect. The work of *Charles Sims*, *Monat Loudan*, *La Thangue*, *Shannon*, *S. J. Solomon*, *P. W. Steed*, *Augustus John*, *Glyn Philpott*, and other members of the New English Art Club is always full of interest, being of great distinction and ability.

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A word must be said in conclusion of the new movement in art in France, Italy, and England. It has been noted how Impressionism in Paris took on a rather too logical and scientific road. Within the last few years a reaction has set in, culminating in what are called *Post-Impressionism* and *Futurism*. The former is rather a vague term, and it is with great bravery that one attempts to illustrate it. But roughly it may be taken to express the aspirations of those artists who, becoming weary of degrading art to a mere method of applying paint, have dared to bring out the more purely pictorial aspects of their art. This can of course be done in many differing ways. In Paris, Florence, Venice, and London, to mention only a few places, one meets with pictures with frankly a purely decorative character. They are probably inspired by Eastern art, and not a few of them have adopted Byzantine conventions with very good effect. They are anti-Impressionist in their aim, *i.e.* they do not seek to represent what we call reality, but adopting certain conventions of a primitive kind they seek to appeal to our admiration in exactly the same way as, say, many Japanese prints do. But they are quite frank in their methods. A red tree is unknown to our visual organs. But in certain compositions such a representation will, combined with the remainder of the picture, give us a far greater natural impression than a photograph. These ideals have been applied with success to the minor arts, especially embroidery. In its purity these ideas have no famous exponents, but many of our younger artists have been influenced by them in no small degree. They lie at the root of the extremely clever and artistic work of such men

as *James Pryde, W. Orpen, R. Connard, Gerald Kelly, S. J. Peploe, J. D. Ferguson*, and quite a number of young artists in Edinburgh, among whom we may mention *W. O. Hutchison*. Indeed, at the moment they are far the most interesting painters of the day, especially as they seem to connect themselves, unconsciously no doubt, with movements in the spheres of music, poetry, and even philosophy. Probably the movement has its limitations, as it is difficult at first to see how they can be applied to portraiture. But in landscape and subject painting they seem to have expressed ideas in their work, not really new indeed, but which have been only unconsciously and perhaps illogically or unreasoningly held by the greatest artists of all times.

The other reactions are of two kinds, *Cubism* and *Futurism*. The former is a technical change. As the Neo-Impressionists saw all things in points, so the Cubists see all things in cubes. Their pictures can only be criticised by their results. They themselves say that it is only some people in the world who see things as they do, and it is unquestionable that in modified form at any rate their technique appeals to our vision. Probably it is a phase. For heightening the colour of a picture it has enormous effect. They have adapted their ideas to the sister art of sculpture, but here the statues he has seen do not in any way connect themselves with the present writer's acquaintance with the human form.

COURSE OF READING

There are few subjects more written about than painting, yet there are practically no standard works either in English or any other tongue. It has been the aim of the present writer to fill the gap for the average unprejudiced onlooker, on whom in the last resort depends the fate of artistic endeavour. The artist may pretend to despise the criticism of the man in the street, but he is economically dependent on him, for it is as essential to painting well as to live well that the means of existence should be at hand. No wonder then that his livelihood is a precarious one. Most of the books on painters and painting deal with the lives of the artist, and a man has not lived till he has died. That is the reason so many great artists get no recognition at all. It is hoped that a perusal of these pages will at least concentrate the willing critic's eyes on the work of the painter There are literally thousands of books written about pictures which never mention the works themselves, but it is not sufficient to tell the student that visiting galleries alone will teach him how to appreciate pictures. No more will the slight knowledge of drawing imparted in our board schools. Far more valuable than either is an acquaintance with the painters themselves, if only, as is not at all usual, they will or can tell you what they mean to say. A golden rule would be, "Go about as much as possible with painters, see as much of their work as possible, find out what other artists say about it, lend to all artists a presumption that they know what they are talking about, read but do not repeat what the critics say, and go and see the pictures again and judge for yourselves. Having formed an opinion, see different work and test your old opinions a few years after." Above all, try and find out what the artist is saying. If you do not agree with his representation, analyse your disagreement and give the artist credit for common sense. You will gradually form a point of view of your own. Unless you are an artist you will not be able to express yourself in paint, but that is not your fault; you will become what all artists of any medium pray for—a sympathetic appreciator.

When you have got a point of view, it is very interesting to compare it with what others have written about theirs. The best-known writers are *Ruskin* and *Walter Pater*. The former is a much more valuable critic of architecture than of painting, but he always stimulates. His *Modern Painters* opened the way to enthusiasm for Turner and the English Pre-Raphaelites, but it is difficult to follow him in his thunderings for or against Titian, Tintoretto, and other Italians. His attitude to Whistler and want of attitude to Manet and his school rather damn him in the eyes of a twentieth-century student, and how such a Mid-Victorian will fare when we have settled down after the war remains to be seen. *Pater* is fantastic and looks at pictures from a literary point of view, but is always supremely interesting. *The Renaissance* and the *Miscellaneous Studies* both contain important contributions to æsthetics. From much the same standpoint J. Addington Symonds wrote his *Renaissance in Italy*, which gives the Italian ideal as seen by the cultured Englishman before the days of Marinetti at its best. It is quite unnecessary to read Crowe and Cavalcaselle's tomes. The only book containing the essentials of painting is R. A. M. Stevenson's *Velasquez*, a small but wholly invaluable work, worth far more than all the tomes on æsthetics ever written. It gives a complete apologia of the Impressionist ideal. The same author's *Rubens* is no better than hundreds of books of a similar kind written every year. That is not to say that these should not be consulted. They are very handy for reference, but the unfortunate fault of nearly all of them is that the writers do not come down to earth and tell the reader why they like or dislike the pictures in question. They tell everything about the writer's mother and his love affairs. The best series are those of Bell and Methuen.

Quite original and excellent on the other hand

is the lately published *History of Painting* by Haldane McFall, which is of far more real value, however much one may disagree with it, than Professor Muther's *History of Modern Painting*, so much of which seems irrelevant to a non-German. In a different form Heinemann's *General History of Art*, divided into countries, is specially handy and ably done—Sir William Armstrong writing the English part. A most excellent account of French Impressionism is given in *C. Mauclair's* little volume, of which there is a good English translation. Oscar Wilde's works and Whistler's rhapsodies amuse and suggest more than they instruct. Modern critics are not a little alive to the deficiencies of their predecessors, and the work of such men as *D. S. McColl* and *Baldwin Brown*, even if enclosed in extravagant bindings, should be consulted whenever opportunity offers. A very sound notion of the aims of the nineteenth-century artists may be formed from them. The Pre-Raphaelite mode of thought is not very intense or obscure, but most of the brotherhood have written much about it. It is not recommended that any books on æsthetics be read with the exception of *Bendetto Croce*. The treatises of German philosophers and their English imitators should be specially guarded against. At the other extreme, time spent on technical manuals of painting and pigment even by unknown authors is never wasted. Midway between these are Reynolds's *Discourses* and such *Lectures* as those of *Clausen*, *Holmes*, and *Herkomer*. Of the magazines devoted to painting, the *Studio* and the *Burlington* are the best. *Rhythm*, which fulminated for and gave illustrations of novel themes and modes, is unfortunately now defunct. Scattered through newspapers and magazines, sometimes declining into book form, are the interesting utterances of *Roger Fry*, *W. Sickert*, *Mark Phillips*, *Bone*.

A word must be said about reproductions. If you wish to take a living interest in painting you must be warned against photographs and black and white drawings. These have a place of their own in the social life of the day, but they engender colour blindness. At best their medium is an unnatural convention. Five minutes spent in the open air, whether in sunshine, rain, or dark, will teach you more of colour than a year of gazing at costly reproductions of paintings you have never seen. On the other hand, when you have loved a picture and formed some notion of it, a reproduction, however limited, will prove a trusty friend, recalling at odd moments vanishing delight. The little booklets of *Gowans and Gray* are specially suited to the penniless student, and it is a pleasing exercise to mark one's criticism of the painting on the margin to help the memory in future reference, and ensures the necessary recalling of the original on which alone one's criticism and appreciation can be based. It is needless to add that one of the aims of this article is to depreciate such patronage of art as is evidenced by the annual purchase of a book of the year's Academy pictures.

J. MACPHERSON.

SCULPTURE

Greek and Roman.—The modern educated man desirous of appreciating contemporary sculpture and learning how it has developed need concentrate his mind only on the work of Greece, Rome, Italy, and modern Europe. It is not proposed in the following sketch to attempt an appreciation or even an enumeration of the extant remains of such early races as the Egyptians, Indians, and Chinese. If the field is limited the quality of the examples will prove of quite sufficient interest.

The earliest Greek work left to us need not detain the student. Examples are scattered in the great museums and show the usual primitive defects. They consist mostly of reliefs stiff in form, wanting in knowledge of the anatomy of the body, conventional in drapery, and stilted in pose and suggestion of action. The frieze of the Treasury of Cnidias or the pediments of the Temple of Ægina at Munich, the Ludovici throne at Rome, and a few separate statues in Delphi and elsewhere are the best examples of the work before the fifth century B.C.

But before mentioning the earliest of the masters, Myron, it is perhaps useful to make a note of the general attitude towards Greek sculpture. In the mind of the man in the street there are two notions, one that the Greeks sought mere types and repeated them *ad nauseam*, and secondly, that the greatest types are the Apollo Belvidere and the Venus de Milo. As to the first, it must be taken very guardedly. It is true that the old artists repeated the same theme over and over again just as the Italians painted their Madonnas and Crucifixions, but in its nature this is not so great a fault in sculpture as in painting. In the latter art the very colours became stereotyped; the modelling of the body can never so degenerate in the hands of a master.

Just because the sculptor is limited in his sphere, within that sphere the room for ingenuity is very great. Again, just as in painting, a great master was copied by his pupils in succeeding generations, but once more the tricks are not so easily acquired. And the Greeks, because of their intimate acquaintance with the naked form in athletics, could never pardon any great departure from reality. They might idealise in certain little details, but so great care was taken by the athletes and the race as a whole of their physique that the sculptor did not require to base his ideals on anything remote from everyday life. As to the second tenet of the average man, it must be clearly understood that the centre for admiration has completely changed. When Winckelmann and Lessing, who were the originators of the modern interest in Greek sculpture, wrote their books, they knew nothing of the Elgin Marbles and other really Greek work. They held up for the admiration of the world what are now known to be only copies of original works, and decadent copies at that. As will be shown, the early work and the later is easily distinguishable, and the demerits of the ancient idols are exactly of a piece with the debased qualities of any other art.

Myron is famous for his athletic studies. Instead of the old rigid awkward poses of the subjects we get activity shown in every muscle: legs and arms are bent in play and the body itself responds to the complicated attitudes represented. His most famous statue is the "Discobolus," or quoit-thrower, the original of which has been destroyed, but the two chief copies by artists very near in date to Myron are the Massini Discobolus in the Palazzo Lancelotti in Rome, and two torsos, one in the Vatican, the other in the Museo delle Terme. His chief characteristics are the muscular distortions of the body, conventional hair, and the indifferent expression of the face in marked contrast to the exertion of the body. The only other statue, copies of which we have, is the Marsyas, the best example being in the Lateran Museum. It represents a satyr standing back in fright, and is supposed to belong to a group in which Athena is the central figure. The bronze statuette of this subject in the British Museum is a much later copy showing none of the master's qualities. Other statues of which we have little or no trace depicted beasts of all kinds and a Hermes. His influence is to be noted in the athletic subjects of the metopes of the Parthenon, the statue of which there are a number of copies of an athlete pouring oil, and the Diomede in the Paladium.

Next we come to the greatest sculptor of all time, *Phidias*, under whose supervision all the so-called Elgin Marbles, the pediments, metopes, and friezes of the Parthenon at Athens were executed, easily the greatest groups of sculpture in the world, now in the British Museum. It is unnecessary here to represent the arrangement of the figures of the pediment or to try

and identify the figures. It is sufficient to note the leading characteristics of the artist as shown by them. It is of course impossible to discuss the wonder of the work as a whole, it is so incomplete, but taking the figures separately and mutilated as they are, they are still the most wonderful examples of sculpture in existence. Perhaps the quality which distinguishes them most from all that has gone before and after is the unique drapery. Hours can be spent minutely examining the details of the three "Fates," as they are called. You may first note the general scheme of each, the harmony of the whole so simple yet so subtle in its unity. Then you recognise the absolute truth of the representation, the form of the body showing underneath the skin and it in turn underneath the thick folds. But take the folds themselves and you will find extraordinary delicacy of treatment—little spaces of light and shade and rest for the eye, yet everything, in spite of the complexity of line, so simple and unified. They are like a symphony of music—wealth of detail governed by simplicity of idea. And compare this after a time with later work, say the Venus de Milo in the Louvre. Notice how perfect the adjustment is, how the sculptor has sailed straight between the Scylla of convention and the Charybdis of exaggerated dramaticism, how virile everything is, yet how untouched by sentimentality. Then glance at the modelling of the bodies again, noting the absence of all staginess in the attitudes, how certain parts are brought into prominence, but never unduly so. Inevitableness and sureness of touch create a great calm over all. Then in the exposed parts, see the delicacy of the flesh tints, to be seen more markedly in the male figures, Theseus and Thyssus, or in the nostrils of the horses. Having drunk in these and other impressions it is interesting to run along the frieze recognising the hand of the master sculptor. A lot of it, of course, was the work of Phidias' pupils, but one cannot help feeling in many parts that either the work was executed by Phidias himself or that there must have been some other genius in his employment. These are the only examples we can with certainty ascribe to Phidias. He was known to antiquity as the author of colossal statues such as the Athena Parthenos and the Zeus at Olympia. A copy of the former in Madrid gives us some idea of what it was like, but another Athena, the Lemnian, a work in bronze, survives in a copy in Dresden and a very beautiful head in Bologna. The quiet and unaffected masterliness of the Parthenos is reproduced again, though in a different way, in the beauty of the hair and the contour of the face, while the Dresden statue gives us some echo of the drapery. In the Museo delle Terme at Rome there is an Apollo which is sometimes ascribed to Phidias. It is an early work of real beauty.

If there is any truth in the slight cast on Greek art, that it tended too much to generalisation and mechanical reproduction of the human body, the fault must be laid on *Polyclitus*. The contemporary, if a little earlier, of Phidias, it was he who seems to have worked out the correct tricks of his art and embodied them in a textbook called the *Canon* and illustrated by a statue. His is the type of Greek art in general as giving the supreme place in technique to proportion, and this, of course, while creating a unique sense of rest in his work, is apt to lead to monotony; but that the Greeks do not think so is shown by the fact that they at least considered him their greatest artist. His most famous statues were two bronzes, the "Doryphorus" or spearbearer, and the "Diadumenos," which represents an athlete placing a victor's wreath on his head. Both have been much copied. We have no early examples of the Doryphorus, but those we have, though only Roman copies, all show more or less the same spirit. Probably the best—it is in marble—is at Naples. The man steps forward, leaning on his right leg, the left foot being raised and hardly touching the ground. The figure as a whole is heavy, or, as we should say, stumpy, and the muscles are all well marked. By his left arm he carries a spear on his shoulder, and the rather bullet-shaped head is inclined in the same direction as the right leg. There is little expression on the face, and the hair, closely curled, does not disturb the original contour of the head. As contrasted with this type we have the Diadumenos, a later bronze, in many of the copies varying very greatly from the earlier work. Polyclitus belongs to the Argive School, with those heavy characteristics already noted, while most of the copies and all the best ones show marked Attic influence, representing much more slender proportions, less impassiveness, and more delicacy of expression. Whether this is wholly due to the copyists or partly to a change in the sculptor himself is doubtful. The Vaison copy in the British Museum is what we should expect from the author of the Doryphorus. Against that may be placed a bronze head in the same museum, remarkable for greater freedom in the hair and the absence of heaviness in the face. And at Cassel and Dresden these qualities are seen to be still more strongly marked, and in addition the texture of the skin is more "Attic." In a complete copy of the Diadumenos found at Delos, and now in Naples, the muscles are far less marked, and when all these are taken together it seems impossible to escape the observation that in his later stages Polyclitus toned down the heavy characteristics which have always been associated with his name. On the other hand there is a great difficulty. The whole tendency of Greek and Roman art was towards effeminate work, lightness of proportions, attitudinising, and sweetness of expression shown by the texture

of the marble. One more example must be mentioned, a very beautiful bronze head in the Louvre, found at Beneventum. Another statue of this master's which has given rise to much discussion was the "Wounded Amazon." The copies fall into two classes. In the first, the wound in the right heart is practically ignored, and the right hand of the woman is raised over the head, thus bringing out the muscular indications we noted in the Doryphorus, an action which naturally would intensify the pain. This is probably the true Polyclitean idea, and as good an example as any is that in Lansdowne House. The others, of later date, show the Amazon pitying her wound, and she draws away her garment from the sore. In the first the drapery is simple and the second more elaborate, the hitching up of the centre part being wholly delightful.

The average man to-day, as was the case in Greek times, when he thinks of Greek or even classical art, usually remembers the various statues of Venus to be met with in the great museums of the world. *Praxiteles'* Aphrodite is the mother of them all. In it was summed up all the feminine loveliness of the time, and it was only in later decadent years that the true glory of his work was spoiled by copyists. The only extant example of his genius is, however, a Hermes, but if we are inclined to regret that the more famous statue is lost, we in this case have cause for unbounded joy in that we really possess in a state of excellent preservation a really original statue of the period. It is almost complete, the right arm and lower parts of the legs alone are wanting. Hermes holds in his left arm an infant, Dionysius, who stretches forth probably to catch a bunch of grapes offered by the destroyed right arm. The figure rests easily and the head is inclined in the direction of the child, but Hermes looks past it. There are no obtrusive muscular indications as in the work of Polyclitus, and the proportions are altogether more slender, yet the modelling is sure and the surface of a beautiful texture giving full effect of light playing on the flesh and a delightfully impressionistic treatment of the hair; the drapery too on the left arm is a masterpiece of restrained realism. But to his contemporaries it was as a sculptor of women that Praxiteles was known, and his love for Phryne, an unconventional lady of the day, has become proverbial. The best-known statue was made for the Cnidians, and the best copy we have, though the drapery at the feet is a late addition, is the Vatican statue with that name. Venus is represented as just entering her bath, her left arm letting fall her garment on a vase and her right probably shyly veiling her nudity. But it is incomplete. One of the chief points to note in the posture is the absence of all exaggerated feelings of modesty. The Venus de Medici, on the other hand, shows a consciousness of sex and spectators unknown in the earlier copy. And again we may notice the sure modelling of the body, especially the chest, the delightful harmony of line and the great ease of the whole figure, poised for the most part on the right leg. The rounded features should also be noted and contrasted with the exaggeration of these qualities leading to sensuality in later copies. A fine head known as the Kaufmann head is to be seen in Berlin, but a still better one and one that is by some considered an original of an Aphrodite or Phryne is the so-called Petworth head, which shows the play of light and shade in a remarkable degree, as well as slighter and more detailed features. Another beautiful copy well worthy of inspection is the Aberdeen head in the British Museum. What is called the Townley Venus leads us on to the class of which the Venus de Milo and Arles in the Louvre are the best known. They represent a woman with the lower part draped, and a still finer and less effeminate copy is seen in a torso in Athens.

We have seen that for the most part the great age of Greek sculpture maintained an impassive expression, but with *Scopas* we find the commencement of that characteristic which is so evident a feature of Hellenistic and later work. Yet he is probably rather older than Praxiteles, that is, he flourished in the beginning of the fourth century B.C. The largest remains of his own or his pupils working under his influence are the sculptures of the Temple of Tegea, parts only of which exist for us. His peculiarities all indicate a passionate outlook on life. The eyes are especially characteristic. Just over the outside corners a small part of the brow wells out, overshadowing the upper eyelid with a remarkable effect, and this is intensified by the distant gaze produced by the widely opened eyelids shortened in length. The nostrils too are dilated, and the lips not completely closed lend a note of passion to the whole face. There is a much mutilated statuette in Dresden, evidently a copy, though a late one, of a Mænad, formerly in the Temple, which shows the lengths this sculptor went in his realism. The subject of course would be just to his liking, but the execution, judging even from this copy, was far removed from later developments. Nearer home in the British Museum we have a very beautiful Cnidia Demeter which repays the closest attention. The story of this goddess wandering through the world in sorrowful search for her daughter and refusing to be consoled is perhaps the most beautiful in Greek mythology, and the idea is completely realised in this work. The passion of a Mænad is not here, but the combination of intensity of feeling and the restraint to be associated with a goddess, albeit a mother, is perfectly understood. The drapery is subtly designed, showing at once confusion and harmony in a most masterly manner, and the whole gives us the representation of true

sorrow as opposed to sickly sentimentalism. If it is a copy it is by a pupil who was very near to Scopas in feeling and execution. Of another work by this sculptor, the Meleager, we possess an excellent copy, also in the British Museum. The famous statue in the Vatican is a late copy, but in the Villa Medici at Rome there is a beautiful earlier copy which it is most instructive to compare with it. English readers will get an object-lesson on the difference between the two copies from a plate in Professor Gardner's *Six Greek Sculptors*. A glance will show the vacant inanity of expression in the Vatican copy and the refined realism of the Medici head. The famous "Ares Ludovisi" is another copy of the artist's work. The remains of the tomb of Mausolus, now in the British Museum, if not wholly by Scopas, must certainly have been executed by those under his influence; and as a typical example mention may be made of the Charioteer from the frieze, the design of the wind-blown drapery and the whole body, mutilated though they are, being very characteristic.

The last name in the great age of Greek sculpture is that of *Lysippus*. Till some years ago the "Apoxyomenus" in the Vatican was supposed to show best the chief qualities of this delineator of athletic life, but Professor Gardner and others have preferred to look on it as rather a late copy, and have given more attention to an "Agias" found at Delphi, which they say sums up, it may be, his earlier style. He was well known to the Greeks as an adapter of the Polyclitean athletic ideal. His works show far more lightness in every way. The stumpiness is gone and elasticity takes its place. By a readjustment of the older proportions of the body, especially in the legs, the height of the victor is increased. The muscles have a less primitive obtrusiveness and greater firmness. But it is in the treatment of the face that the difference between the two sculptors is most marked. The Agias connects with the Scopas style with a variation. The eyes by somewhat similar means become concentrated, the gaze intensified, the face itself is made smaller, the hair is more impressionistic. In the Apoxyomenus, on the other hand, though there is a touch of all these traits, everything bearing on the height being intensified, the general expression is far less dramatic and realistic, being far more generalised, and the muscles of the body are more learnedly detailed. Lysippus was the Court sculptor to Alexander, and executed many commissions for those who devoted themselves to his cult, so that most of the emperor's busts we see in museums show his influence. One of the best in the Agias style is a head in the British Museum, easily recognisable from its coils of hair hanging down on each side of the face. The expression is a very fine one, from an artistic point of view, the eyes showing the manner of both Scopas and Lysippus.

The Hellenistic Age.—After the fourth century, as has been noted so often, sculpture declined, becoming more generalised in expression, effeminate in sentiment, and dramatic or "stagey" in action. But in what is called the Hellenistic age, *i.e.* the years immediately following the fourth century, there were executed some works which still hold our admiration. Of these, passing over the set of Niobe's children in the Uffizi Gallery in Florence, mention must be made of a beautiful statue of a young man excavated at Subiaco, now in the Thermæ at Rome. If the pose shows how late it was carved, the modelling and delicacy of the flesh texture is worthy of prolonged study and leads us back inevitably to Praxiteles. But the best-known statue of this period, and not unworthily so, is the "Victory" from Samothrace, which has such an imposing position in the entrance staircase of the Louvre. In spite of all the dramatic power and restlessness of the drapery, there yet remains not a little of that artistic restraint we saw in the Parthenon "Fates," and the modelling of the figure seen through the dress is superb. Better known, but with much less good reason, is the so-called "Dying Gladiator" or Gaul at Rome, in which the faults observable in later works appear. There is no divine seriousness: little inevitableness of technique and none of composition, and the hair and expression show how subsidiary in the sculptor's mind was his art to dramatic feeling—all the world to him was a stage.

Mediæval Sculpture.—It is perhaps unusual to separate the sculpture of our churches and cathedrals from the architecture, but for the sake of completeness it is convenient to do so. After the Roman world ceased to exist and the influence of Roman copyists of Greek work no longer dominated the artistic world, there is a big gap before sculpture proper came to its own again with the Renaissance. But the gap is not so large when we glance at the architectural sculpture of the period. We then find that, though in a different direction, the sculptor's art was by no means without expression. As has been noted, every workman was an artist in stone in the mediæval period; the guilds would permit no scamped work, and thus the men whom we should now call masons produced sculpture that all the world journeys to see. In the Romanesque period we do not find much ornamentation either in the fronts of the churches or in the carving of the capitals, but to the twelfth and thirteenth centuries it abounds in all countries. In Chartres Cathedral, probably the finest building in France, the early figures show strong Byzantine influence, but little injured as they are they give great æsthetic satisfaction. These along with the later work make the sculptures on the west front and the north and south porches the noblest display in the country. They are untinged with Roman

decadence. If primitive, they show extraordinary delicacy of treatment and beautiful execution. They are not things by themselves, but, like the stained glass within, they deeply intensify the effect of the building as a whole by their individual merit. Of much less equal merit and later in date are the figures in Amiens. Those on the west front yield in importance to those in the transept, especially on the south side. They have not been so well preserved as those at Chartres, but they form fitting companions to the woodwork of the choir in making the open Bible of this people's church. To mention one other town—Rouen possesses work of still later date (fourteenth century) in the Cathedral, St. Ouen, and St. Maclou. In these we do not observe the same delicacy of treatment as in the earlier work, and comparison of the three towns' fronts gives an excellent illustration of even at this time the flamboyant trend of the sculptor's tool.

The excellence of the earliest sculpture of the cathedrals at Florence, Pisa, and other towns of Central Italy, pales before the brilliant richness of the capitals of the Doge's Palace in Venice. Ruskin has treated so fully of these, and so justly on the whole, that it is unnecessary to repeat anything here. They repay hours of minute examination even under a broiling sun, and no building ecclesiastical or secular can show greater wealth. The best of them fulfil all the canons of sculpture of any age, and the worst would induce admiration, if they were not put to shame by their more lifelike and exquisite brethren. At the other extreme are the famous figures inside and outside Milan Cathedral, which in spite of their costliness seem to infringe all the ideals of architectural sculpture, while taken by themselves they leave the onlooker unimpressed. They might all have been ordered from a first-class Birmingham firm.

It cannot be said that in quantity England can compare with France in the sphere of architectural sculpture, and indeed it has been the fashion to ascribe any that does exist to foreign workers. Yet there are no real grounds for doing so. Some of the most interesting early Christian sculpture in the world is to be found in the Celtic stones or crosses of Scotland and Ireland, which show in a remarkable way both decorative ideas and exquisite execution. It is unfortunate that for the most part they are not easily accessible. They are formed, of course, from conventional geometrical patterns, but they and their contemporary work in bronze and parchment show how highly trained the native workers in the monastery or in the workshop must have been. As in other countries the earliest stonework shows great primitiveness. At first the architects of our churches scorned decorative detail, nor did the Norman style leave much room for it, and it is not till the early English period that we find any prominence in a building given to sculptured figures or capitals. As to the latter, it may be stated at once that with the development of English Gothic the carving in low-relief of capitals, corbels, &c. reached an excellence and refinement of natural representation unsurpassed in any other country. In fact, in the writer's view, the fresh directness of these representations seem to him the crowning glory of English work, and thereby usually distinguish it from that of other foreign countries. More ambitious are the famous angels in the spandrels at Lincoln, which are in the best style, the attitudes and expressions of which have no false notes, but are noteworthy for exquisite workmanship. At Salisbury and Westminster they are almost as good, but pride of place must be given to Wells for its varied wealth of sculpture. Here all details are delightful in their purity and satisfying in their design. Only less rich is the west front of Exeter, though the stone has weathered badly. Purbeck marble, a native Dorsetshire limestone, because of its polish gave rise to a new school of workers, chiefly to be seen at Westminster and the Temple Church in London. In turn it gave place to alabaster and wood, chiefly used for tombs. Being easily worked, it failed to exact the highest skill from its carvers. But the downward turn had been taken, the difficulties surrounding the earlier workers had made artists of them, but with the Perpendicular style we share the flamboyant nonsense of our continental friends.

Italian Sculpture.—We have now to return some years and trace a unique development of sculpture in Italy from the earliest Gothic period to the full Renaissance. Our first great names are the *Pisani, Nicola* and *Giovanni* of the thirteenth and *Andrea* and *Nino* of the first half of the fourteenth centuries. In the hands of these and their pupils the art is still subordinate, or rather a part of architecture, and as a result reliefs of all kinds abound. It must always be remembered, and we note it especially in architecture, that the Roman element never really disappeared in Italy. Men of artistic sense seem at no time to have been quite indifferent to such remains as were public of the earlier art, though they may have misunderstood their ideals. Thus we find that in Nicola Pisa's pulpit the influence of classical vases is remarkable. The northern artists had no such examples before them, so we find a fresher, more realistic treatment in their carving as in their architecture, for both were one and the same. Other examples of the early Pisan school are the Sienna pulpit, a fountain in Perugia, and the pulpit of S. Andrea Pistoja. The last, by Giovanni, shows much less imitation of traditional types, freer imagination and execution. But attractive as it is to dwell on their works and those of Andrea, whose bronze gate in the Baptistery must never be overlooked in admir-

ing Ghiberti's later work, we must hurry on. The beautiful sculpture of the Doge's Palace has already been mentioned, and is of this period. As has been noted, it is worth risking the contumely of being a prefervid Ruskinite to say that in execution, composition, beauty and richness of detail and quaintness of imagination they surpass anything of their time. Orcagna, a pupil of Andrea, is best known for his gorgeous shrine in Di San Michele in Florence. His profession of goldsmith is very evident in it, yet its architectural design is carried out with consummate success. We now pass to the Baptistery gates at Florence, and if we wish a lesson in the achievement of Ghiberti, all we have to do is to test in the Bargello the decision of the judges in the competition, for Brunelleschi's and the winner's trials are still to be seen there. Again, it is most interesting to compare Ghiberti's first gate with his second essay. The latter, though the more famous, shows the beginning of that intense love of experiment, of pushing knowledge to its limit, which unfortunately is not an artistic quality. We admire the wonderful perspective, the audacity of the realistic execution, but we shall probably return to the first gate as better realising the ideals, if limited, of bronze relief. Only ten years separates the lives of *Ghiberti* and *Donatello* (1386–1466), and with him sculpture regains its primacy as an art. His works are excellently and completely shown in original or cast in the Bargello. The St. George made for the outside of Di San Michele may interest English visitors for its subject, but the David sums up best the essence of the artist. Purity of sentiment, mastery of technique, and singleness of purpose characterise all his work. Chief are the little John the Baptist, the organ stalls in the Cathedral Museum, the delicate relief in S. Croce, the "Judith and Holofernes," the bas-reliefs of the pulpit and the reliefs and statues in the old sacristy of San Lorenzo, and the equestrian statue of Gattemalata in Padua. It is doubtful whether anyone has embodied so adequately the Florentine ideals of the period as did Donatello: you note in his work the first flush of a great corporate movement in intellect in art, and perhaps above all that tendency towards the rhythm of music that Walter Pater considered the minor reality of all art. His pupil *Verrocchio* is one of the most remarkable names of all time. The statue of the Condottieri Bartolommeo Colleoni before the Scuolo di San Marco in Venice is the greatest equestrian statue in the world. It is not wholly his work, for he died before its completion, and its details were filled in by *Leopardi*. Horsemen might take a lesson in riding from its muscular display, but it is far from being a mere feat in modelling. No line of the work is out of place, the proportions of horse and rider are, one would think, perfect, the exact position of the horse on its pedestal is itself a bit of decorative and realistic genius, and there is over all the true artistic quality of restraint. But he was not a one-book man. His bronze of David in the Bargello is famous, and justly so, for it is also the prototype of the notorious Leonardo face, Da Vinci being his pupil, but it may be studied for no mere facial coincidence. Many refuse to the form of the body and its drapery the quality of truth to the subject, but to the present writer at least such criticism seems misplaced. One sees in the curious half-shy, half-boastful figure the essence of the Bible story humanised. Here is a young boy with a big cuirass in the first flush of victory. He is not quite sure whether he has done right or wrong, but the roguish feeling will out. The quaint dress intensifies the expression, making all of a piece—an altogether delightful study. None of his other works come up to these two, but those in the Bargello are well worthy of attention.

The sweetest name in Italian art is undoubtedly *Luca della Robbia*, the inventor of that glazed terra-cotta ware which has charmed posterity as much as it charmed his own patrons. Apart from that it is sufficient to mention his organ loft to be compared with Donatello's in the Cathedral Museum. Both are very beautiful in different styles. His terra-cotta work is remarkable for delicacy of modelling and line, sweetness of portraiture, simplicity of theme, and a perfect adaptation of style to medium. The best place to study them is again in the Bargello, but luckily we have one or two specimens in South Kensington, and they are to be found all over Florence. His nephew, *Andrea*, of the infants opposite the Spedale degli Innocenti in Florence, was no unworthy follower, but after him his descendants kept the secret of manufacture, but did not inherit the ability of its inventor. Luca was content with delicate blues and whites: gaudiness of colour, crudeness of design, and feebleness of execution are the characteristics of the later work, which unfortunately are most to be met with in our museums. Better followers of Luca were the sculptors *Rosselino*, *Mino da Fiesole*, and *Benedetto di Magani*. The first named is best known for a wonderful monument to the Cardinal de Portyallo in San Miniato in Florence. The canopied design is a masterpiece of its kind and the figure admirable in execution. It is not too much to say that it reaches the highest watermark in Renaissance work of this description, and is a splendid touchstone for judging other sculptured monuments. Mino fares well in the comparison, though his work is mannered, and Benedetto's best claim to fame, and it is not a formidable one, lies in the pulpit in S. Croce. *Desiderio da Settegnano* was given rather to exaggerated ornamentation, but this does not prevent his monument to Carlo Marsuppini in the same church from being a

masterly piece of work. In the Bargello there are many works, small in size but delicate in technique, of all these sculptors which ought not to be overclouded by the greater masterpieces to be seen in this museum. *Andrea Sansovino* of Florence continued the floridness of the late fifteenth century, and his pupil *Jacobo* of Venice, whose statues on the Scala d'Oro are not nearly so fine as his bronze doors to the sacristy of St. Mark's, is entitled to great fame only as an architect. For sculpture had fallen once more upon evil days. The "Mercury" of *Gian Bologna* (1524–1608) in the Bargello is famous, and if it had not been so much re- or perhaps misre-produced we might more appreciate its undoubted cleverness; but other works, notably his equestrian statues—one opposite the Palazzo Vecchio, the other in the Piazza dell' Annunziata (the latter in spite of the literary association of Browning's "Statue and the Bust")—fail to impress us.

Benvenuto Cellini (1500–1571), that most adorable literary rogue, was made of finer stuff, but even he delights us more as a figure than as an artist. Probably the famous Perseus in the Loggia de Lanzi and the few statuettes in the Bargello do not give us a satisfactory notion of either his versatility or the excellence of his technical abilities. He stands to us now as the ideal of the artist craftsman, a personage the best men of the twentieth century are seeking to revive. It was not only as a jeweller that he turned everything he touched into gold. Contemporary with Cellini there lived the overpowering *Michael Angelo Buonarroti* (1475–1564), whose life and work stand out as a rock overshadowing all around him. Painter, draughtsman, poet, architect, scientist, and politician, he excelled all others by the power of his thought and the excelling nature of his technique in the art of sculpture. His best-known works are the "David" in the Academy, and the "Pieta" in the Cathedral of Florence, a more famous "Pieta" and the "Moses" in Rome, the "Bound Captives" in the Bargello, Louvre, and Boboli Gardens, and the tombs in S. Lorenzo, Florence. Of these we may take the last as illustrating his style. His life was a weary one. One of the first intellectuals of the Renaissance, a man of extraordinarily deep religious feeling, he was doomed to be the plaything of successive unappreciative patrons. Like every great thinker, he arrived at no melodious and simple philosophy of life. He was never satisfied. All this is displayed in his work, most of which, probably intentionally, is left unfinished. The tombs are placed in the new sacristy of S. Lorenzo designed by the sculptor, and commemorate the two Medici princes, Guiliano and Lorenzo. The former, surrounded by Day and Night, is a cheerful figure, full of energy and confidence. With what a proud grasp does he hold the baton. He is exactly the opposite of the traditional strong quiet man the stage and novels produce for our admiration. He is full of "trenchant force and will like a dividing spear," a prince of the Renaissance world. Opposite this tomb lives for ever the epitome of the intellectual life of man. Full of gloom this idealised figure sits, pondering over life and giving no answer to his thoughts. Beneath him sit Evening and Dawn, so different in their attitudes: the imagination runs riot in conceiving what these figures represent. No artist in any medium has so successfully depicted the higher life of man, man's nature or highest self, than did Michael Angelo in the sacristy. It is unnecessary to add that the lives of the Medici do not correspond. His technique is noticeable for the wonderful anatomical modelling, the beauty of the flesh colour, the truth of the light and shade, the reality of the postures, the absence of all prettiness or sentimentality. The designs of the individual figures and of the whole form one glorious symphony, intricate in detail, grandly simple in their harmony. A divine quiet overrules all and compels worship. No other church or edifice gives rise to higher emotion than this sacristy. Death is shown in her victory, death with doubtful hope of better things, but it is the death of men who have fully lived. Some of the figures, as also much of his other works, are unfinished, and it is questionable whether the artist, like Rodin, with whom he interestingly compares, intentionally adopted this impressionistic manner. It is unnecessary to argue the point, as it is evident that in no cases except the "Bound Captives," at which he was at work when he died, do the statues suffer any detraction because of their condition. It is interesting to note for students that wax models of the tombs, purporting to be originals but showing somewhat different designs, are to be seen in the Scottish National Gallery.

French Sculpture.—We have suggested how Italian monuments took on a *baroque* quality, but it may be added that in other countries Renaissance sculpture presents a sorry spectacle. The difference between the old mediæval work, so lovingly executed, is evident in nearly every country. Here and there—in Nuremburg in particular—you find minor work such as altar-pieces and statuettes which redeem the age from oblivion, while again a few tombs stand out in our minds as connected with better days. Floridness, however, abounded. The Louvre has some fine specimens of the work of *Goujon* and his colleagues, the contemporary of *Gian di Bologna*, but this and succeeding generations were very barren of any real sculpture. Perhaps Spain is as interesting as any country from the point of view of sculpture of the seventeenth century. Religious enthusiasts of that land now as then loved coloured images on their

altars to carry during Holy Week. *Montañes* is the first and greatest name, and his best work is in wood. Every town in Andalusia and every church in Seville boasts one of these painted Madonnas, but the genuine statues, for example in the unapproachable University Chapel of Seville, should not be ignored. *Puget* (1622–1694) is the best of his time in France, and later *Pigalle* and *Houdin* introduced that inanimate type of art founded on rank ignorance of technique which passed for so long as classic there and in England, to be varied only by profound sentimentalism. *Rude* and *Carpeaux*, on the other hand, had a personal if decadent vision which had enormous influence on more modern sculptors. The best-known figure in the later eighteenth century in Italy was *Canova*, but it cannot be said that either at the Frari Church or at S. Croce his work is at all impressive. England is justly proud of *Flaxman's* designs, but his large pieces of sculpture are failures, and the later *Chantrey* will not keep anyone's interest away from modern work.

The change, the awakening to reality we have seen in painting, came from France, and in no art was there greater need. Painting had realised itself long before the Franco-Prussian war, but it may have been the very success of the Fontainebleau school, satisfying as it did to a great extent most of the aspirations of artistic man, that allowed the sister art to wander divorced from reality in the desert. True, there were some able men working at the time, *Idrac*, *Gérome*, *Beguer*, and *Frémiet*, but it was not till after France had recovered her place in the nations and was full of patriotic vigour that results of her ambition became evident. Four men are conspicuous in the movement: *Jules Dalou*, *Rodin*, *Meunier*, and *Bartholomè*. The first, as we shall see, in his " refuge " during the Commune bequeathed his influence to England, but on his return to Paris he wielded a still greater because more general sovereignty. He is the link with the older men. He accepted the older traditions, but gave them life. To take the dead first, Meunier, a Belgian, introduced the working-man into his art, but not with any sentimental object. He saw the nobility of labour, the sorrows of the miner, that modern hero of chivalry, he looked on them as expressing most powerfully the deepest and truest feelings of modern life, and above all he represents his vision in consummate technique and design. His best works are " Le Guron " and other miner studies, and "Ecce Homo" in the Brussels Museum.

Rodin is a different personality. He is the prince of moderns, reminding you at once of Phidias and Michelangelo. To the deep sentiment of Meunier he adds the thought and imagination of an intellectual man, and before everything he has infused glowing life into his works. He knows life in its infinite variety—sensuous pleasure, wracking doubt, voluptuous love, frenzied despair, all are grasped clearly by him and transformed into marble or bronze. His modelling, one would think, is the perfection of plastic art, sensitive and sure. Never once do you find in all his varied imagination one touch of affectation nor any feebleness of design. The best gallery to see his work in is the Luxembourg, which has given him only his due in housing the splendid collection there. Amongst them are to be noted "The Kiss," "The Hand of God, "St. John the Baptist," and the "Danaide." "Le Penseur" is fittingly placed in front of the steps of the Panthéon.

Bartholomé is probably the greatest and finest sculptor of the modern school, but unfortunately there is no gallery to exalt his name in the public eye. He does not depend on any subtlety of intellectual imagination; his subjects are what are called popular, that is to say subjects of everyday interest and therefore of the essence of life, but no one is further from the commonplace. He has all the brilliance of the traditional outlook on life of his countrymen, but, refraining from fireworks, contents himself with a purely plastic ideal, and the result is wholly satisfying. The Luxembourg has one beautiful specimen of his work in marble.

Sculpture in England.—To make any attempt at a complete glance at English sculpture we must unfortunately retrace our steps a moment. We have seen the work of Gothic days to be of great interest. After the fourteenth century, however, there is little to excite us till the nineteenth. The porch of St. Mary's, Oxford, has been ascribed to *Nicholas Stone*, and the shades of Inigo Jones would probably not be insulted. The Botanical Gardens are a much better memento, though his contribution to Holyrood Palace is not without merit. *Colley Cibber's father* is the maker of the two mad figures on the Bethlehem Hospital, but *Grinling Gibbons* is the best English absorber of the Renaissance, and his James II in St. James' Park, though ludicrous in subject, is excellent in technique. Far from it in every artistic quality was the work of the rest of the " classical " school. We have seen how Greek artists, while merely representing conventional and traditional ideas, were so familiar with the human body that they never, even when the subjects seemed least promising, forgot the " brute " that is in nature. If a God was represented, he was a super-man, not a generalised idea with all human elements ignored. Seventeenth-century sculptors did not grasp this. They aimed at vagueness of theme, thinking they had reached a truly classical mode of expression when they showed in marble a repose which was based wholly on lifelessness. Greek sculptors, however, if they ignored the accidents of life, did not thereby lose vital force. Westminster and St. Paul's are full of this period's work. *Flaxman*

is as good a representative of his time as any, and he is rightly most famous for his illustrations and not for his statues. This spirit, or lack of spirit, lasted till the middle of the nineteenth century, for *Chantrey* (in spite of his busts) and *Foley* need not detain us, for only a little later in date there came our greatest sculptor, *Alfred Stevens* (1818–1875). The model of his Wellington monument should be studied very closely in the Victoria and Albert Museum, and every design in the room at the Tate Gallery, as well, of course, as the monument itself at St. Paul's. Both from the sculptor's point of view and that of the architect this is a work of outstanding genius. The figures, for example, of Truth and Valour for variety and harmony of design and beauty of detail make them comparable with the greatest works in marble, while the sculpture at Dorchester House repays any trouble there may be in getting permission to inspect it. The work of *G. F. Watts* is rather eclectic. His "Vital Energy" in Kensington Gardens is well-known, but the "Clytie," a bronze of which is in the Tate Gallery, and the group at Eaton Hall, are still more worthy of admiration.

Stevens was unacknowledged in his day, and his designs met with ludicrous indifference. The originator of the modern English school is *Jules Dalou*, whom we have noticed among his French brethren. During the Commune he taught in England and instilled with great success the true methods of his art into his pupils. *Hamo Thornycroft* was the first to show his influence by his "Artemis" at Eaton Hall, a singularly beautiful composition, and the "Teucer" in the Tate Gallery. Trafalgar Square, Westminster, and the Strand all show his admirable work. *Onslow Ford*, again, is more commonplace, though his "Irving" in the Guildhall Gallery is a fine piece of work. *J. M. Swan* is a remarkable technician, best known for his studies of animals. *Alfred Gilbert* teems with ideas and works them out in the cleverest of ways. Few who pass through Piccadilly Circus can pause to look at the Shaftesbury Fountain, but its beauties are worthy of a more secluded resting-place. Winchester has a greatly conceived statue of Queen Victoria from his hand, and others of his works are the bronze "Icarus," the statues of Earl Howard at Bedford and of the Duke of Clarence at Windsor, and the reredos in St. Albans Cathedral. Of the men whose work we can see at the Academy, mention must be made of *Sir George Frampton, Sir W. Goscombe John, H. A. Pegram, Albert Toft, W. R. Cotton, Gilbert Bayes, Bertram M'Kennal,* and *Alfred Drury*. The last named is well seen in the War Office sculptures, and the work of the first two is noticeable for good technique. More ought to be said of *Mr. Derwent Wood*, who with *Mr. Harvard Thomas* is probably the best of the younger men. "Lycidas" and "Thyrsis" by the last mentioned have been much abused, and both have won ultimate fame for their exquisite workmanship. *Mr. Epstein* has a manner of his own, very fascinating in its outlook and very clever in its technique. Of the Scotsmen, *Mr. Pittendrigh Macgillivray* and sometimes *Mr. Birnie Rhind* show how eager sculptors in Edinburgh and Glasgow are to blot out the misconceptions of their predecessors: and it is a matter for congratulation that they are well employed even by official bodies.

COURSE OF READING

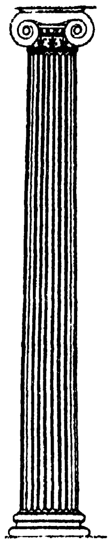
The works of the brothers Gardner form the best reading on Greek and Roman sculpture, especially the *Handbook of Greek and Roman Sculpture* and *Six Greek Sculptors*. The mediæval period is dealt with in most of the chief works on architecture, and Ruskin's *Stones of Venice* give all the necessary information about the Doge's Palace. Otherwise cathedral sculpture is noticed only in guide-books and short essays in such journals as the *Architectural Review*. Renaissance sculpture, on the other hand, has been much written about, and all the chief sculptors have many biographies. Lord Balcarres' *Donatello* is one of the best. Addington Symonds gives prominence in his *Renaissance in Italy* to the art, usually with ability, but one must be fully warned against reading these books before seeing the originals. Frenchmen naturally have not been slow to dwell on Rodin's genius. Sir W. Armstrong is enthusiastic over A. Stevens, but it must be admitted that there is very little literature on modern sculpture.

Another method of instructing students is used, namely, the making of casts. These vary very much in value. Even the British Museum has a great many bad casts, but modern communities in Britain are waking up to the necessity of having competently cast reproductions of the most famous works. Far-away Aberdeen has an excellent collection. Many instructive days may be spent in the South Kensington Museum.

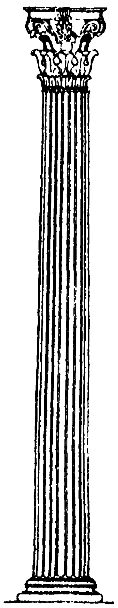
J. MACPHERSON.

ARCHITECTURE

Greek and Roman Architecture.—Any description of early Egyptian and Asiatic architecture would put a sketch such as the present quite out of proportion. As much space as possible must be given to the ideas and examples which the ordinary traveller meets on the Continent or at home. If he is lucky enough to study remains in Egypt or India he can easily consult expert opinion on the subject. All that is intended in the following brief review of Architecture is to stimulate if possible in the man-in-the-street an appreciation of the churches and buildings he comes across at every turn, and thus perhaps give more opportunity to the artists themselves, who without such apprecia-



Greek Ionic Column



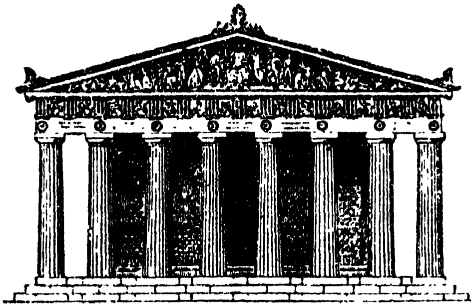
Greek Corinthian Column. Monument of Lysicrates

tion must remain caviare to the general. There are writers in these days brave enough to disparage all modern architecture, attempting to find salvation *pro tanto* in Egypt. A humbler aim is here held, and all that needs to be noted is that for the most part the trend of Egyptian art is antagonistic to that of Europe, though, especially in small details, there are numerous resemblances between the old and the new.

For our purpose, then, we may ignore even the dimensions of the Pyramids and the great Sphinx and make a start with a fully fledged style, that of the Greeks. The chief aim of this race in all its art was "nothing in excess," and it is fitting that in those temples which were their chief buildings the maxim should be given supreme place. Thus we find that after the practical aim of the building had been found out the architects chiefly busied themselves with the sense of proportion. That is the secret of Greek architecture, and thus the cause of its great simplicity and dignity. Indeed it can hardly be disputed that the Greek principles of construction are taken from the earlier mud-dwellings. The arch was very seldom used. The temple was simplicity itself. It consisted of an inner shrine, within which was placed the statue of the god or goddess. This was surrounded in the shape of a parallelogram by pillars constituting the *naos* or *cella*. Surrounding this was another pillared space composed either entirely of columns or with side-walls. An entrance porch to the naos (*pronaos*) with sometimes a back-temple (*opisthodomus*) completed the building. The whole was usually raised on three steps. On the two end façades a triangular pediment was placed, often filled in with sculpture. On the top of the columns there rests the entablature, consisting of three parts. Immediately above the capital of the pillar there is the plain *architrave*, above that is the sculptured frieze, and still higher the cornice. In the frieze above each column is placed the *triglyph*, another of which is placed in the space between. The space between the triglyphs is called the *metope*, and was usually filled with reliefs. In the column we have, besides the shaft, the *abacus* or capital, supported by a moulding called the *echinus*. The columns are of three kinds, giving rise to the different styles employed. The oldest is the Doric, later comes the Ionic, and latest and very little used in Greece is the Corinthian. The form of these three pillars is easily recognisable from the illustrations given. It is to be noted that the Doric column has no separate base rising immediately from the steps below.

The chief building in the Doric style was the Parthenon in Athens. It is, of course, one of the best-known buildings in the world, and most museums have models of it in some form or other. The famous Elgin Marbles in the British

Museum (*see* Sculpture) form the pediments and friezes of the building. It was the chief temple of Athens's patron goddess, Athena or Wisdom, and stood in the Acropolis. It was built in the greatest period of Greece's prosperity, in the reign of Pericles, about 438 B.C.,



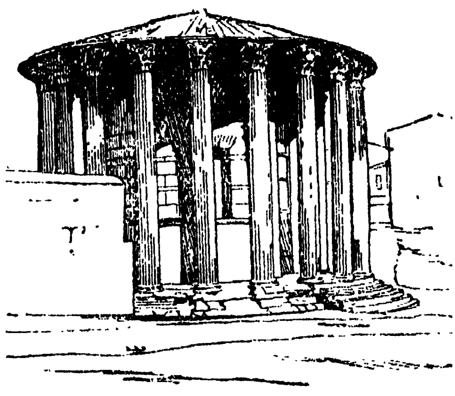
The Parthenon

Phidias being responsible for most of the sculpture. Its entrance gateway or *The Propylæ* is perhaps the chief other Doric building. Its interior is in the Ionic style, and the combination of the two is exceedingly harmonious. Less severe than the Doric, its birthplace was Ionia, *i.e.* Attica and Asia Minor, the latter place affording most extant remains. Chief of these were the temple to Artemis at Ephesus, the temple of Nikeapteros, and the Erectheion, both at Athens. In the latter was the famous porch, the pediment of which was supported by sculptured female figures (Caryatides). The Corinthian style is not found in general use till the Roman period. The Choragic monument of Lysicrates at Athens—a much-reproduced work—is the best-known example. The style is more ornate than is consistent with the simple native Greek ideal.

Roman Architecture.—After the Hellenistic period (*see* Sculpture) Greek architecture gives place to Roman. Superficially the styles are the same, constructionally and artistically there is a world of difference. Let us notice a few changes. The Greeks built their temples of huge blocks of marble placed one on the top of the other without any mortar binding them together. The blocks are very carefully worked and finished. The Romans had no time for this, so they invented the use of concrete faced with brick, stone, or marble. This had the great advantage that it could be employed anywhere, irrespective of geographical conditions, and that the greater part of the walls could be constructed out of almost anything and by unskilled workers. It is to be noticed carefully that in neither case was there any vertical thrust, so important a problem in Gothic architecture. The Romans bound together all the material used into one mass of concrete—dead, so to speak. If stone and mortar had been used, as in modern buildings, the walls would have been pushed out without buttress or other support.

Vaulting was another of their discoveries. The Greeks contented themselves with the waggon-head vault, by means of which the roof is supported on only two sides of the rectangle by semi-circular arches. The Romans intersected the two arches, thus giving the roof support at its angles, and leaving the rest of the wall free to be used for windows. They also developed the use of the dome. Both its use and that of the arch no doubt were learnt from the Etruscans. Enormous spaces of any shape were covered by means of the arch, the cupola, and the dome—granted only, it must be repeated, that concrete was used in the construction. Indeed the Romans departed altogether from the Greek ideal. The latter aimed at external beauty and simplicity. The Romans invented all sorts of engineering devices, rendered necessary by the fact that two or three stories were given to their buildings instead of one; and using the orders mostly for ornament and in great profusion, centred their greatest attention on the interior decorations.

Of temples in Rome itself we have what are now the churches of S. Maria Egziaca and S. Lorenzo, those of Venus and Rome and of Jupiter Ionaus, besides many columns of others. There were also circular temples, the most famous being the Pantheon and the temple of Vesta, both

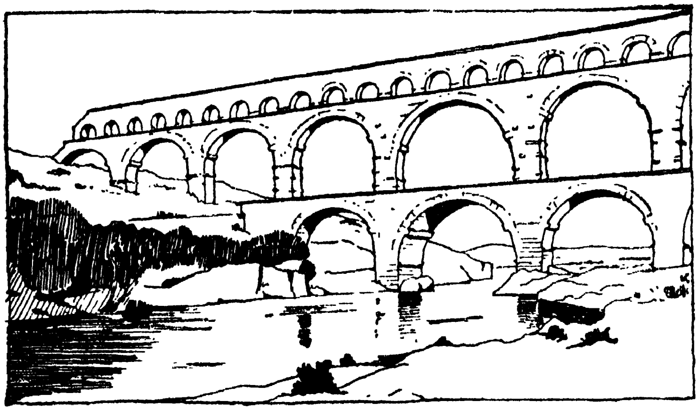


Temple of Vesta, Rome

at Rome. The bronze doors in the former are considered to be originals.

Apart from the Forum or public meeting-place, of which each city had at least one, the most interesting Roman buildings are the Basilicas and the Thermæ. The Basilica or Law Court was a simple rectangular building with aisles, having an entrance at one end and a raised dais, often in an apse, at the end, in which the magistrates sat. The best-known example is that of Trajan at Rome. Its date is about A.D. 98. The

Baths of Caracalla show us what the Thermæ were like. Not only is there accommodation for 1600 bathers in the central buildings, but apartments and shops of every kind, recreation rooms, halls for lectures and plays abound in the enclosure. The inside was gorgeously decorated with marbles, mosaics, paintings, and sculpture. A part of the great hall (*tepidarium*) of the Thermæ of Diocletian was converted into the church of S. Maria degli Angeli by Michael Angelo. Amongst other buildings of which remains exist are the amphitheatres and theatres (Coliseum, Verona, Nîmes, Seville), triumphal arches (Titus, Septimus Severus, both at Rome), aqueducts (Pont du Gard, Nîmes), and bridges (Cordova), palaces (Cæsar's, Rome, and Diocletian's, Spalato). Besides these there are the ordinary houses of the Romans, which can be so well viewed at Pompeii and Herculaneum. The "city" itself cannot give us such a true idea of the Roman atmosphere as produced in architecture as these towns which were overwhelmed by Vesuvius in A.D. 79. The "House of Pansa" there shows all the different rooms and their uses, and bears an interesting comparison with our own modern dwelling-houses.



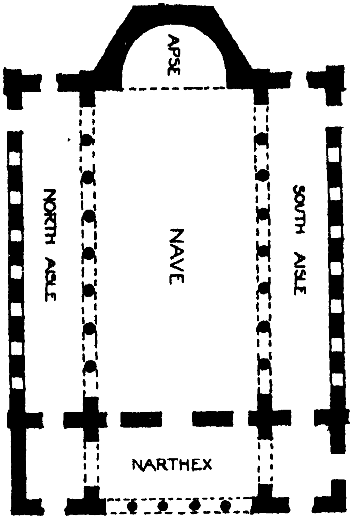
Pont du Gard, Nîmes

Romanesque Architecture.—The link between these early Christian basilicas and what we call Gothic architecture is found in the Romanesque churches. We have seen how the first Christians, on the State recognition of their religion, probably housed themselves in the buildings of the older cult. Now Roman, now Byzantine, now barbarian influences arose, but we have very few remains till we come to the eleventh century. We may take Italy first as showing the Roman influence more. Here the basilica plan of buildings still survived. Galleries are common, brick faced with marble is more frequent than stonework, the openings are small and simple of the Roman semi-circular form, the window tracery is primitive, the roofs are sometimes flat, sometimes vaulted, there is seldom a triforium, and often no clerestory. Transepts are rare and domes common, and the apse is universal, with often a raised choir and crypt. One of the best examples is the Cathedral of Pisa, of the last half of the eleventh century. The tiers of small pillar arcades in the west façade are very simple and beautiful. The Leaning Tower, a century later in date, the foundations of which gave way during its construction, is well known, and the circular Baptistery is not so fine as that of Florence. The domes of the two Baptisteries should be contrasted with one another and with that of St. Paul's. Internally the red and white marble gives the building a more Roman aspect than is noticed in the Northern European work of the same period, and the columns here, as elsewhere, should be compared with the common English Norman type, so much thicker in circumference and lower in height, and with its cushion capital.

A much smaller but no less beautiful church is that of S. Meniato, Florence. The basilica plan has in it been developed, the building being divided into three parts by piers. The open and richly coloured timber roof is a marked feature as well as the variegated strips of marble, the pavement, the raised choir, and the crypt. It forms a striking contrast to the later churches in the city. In the south, as for example in the Cathedral of Monreale in Sicily, Mahometan and Byzantine influences are to be noted in the lanterns at the crossing, the mosaics, and the roof, while in the north there is a good example of the Roman atrium in S. Ambrogio, Milan.

In the South of France in the eleventh century the Latin influence was still predominant. The basilica type of church without aisles is common, domes are a feature, and, as at S. Front, Périgneum, we see a very interesting adaptation of the Byzantine style which Venice favoured. But it is in the north, in Normandy, that we see

the beginnings of the new trend of thought, and probably the best examples are to be found in Caen in La Trinité and St. Etienne. The west front of the former brings us at once into a new atmosphere. The simple round arch has lost its Latin completeness, the plan has taken on



Basilica Plan St. John Studion, Constantinople

that beautiful cruciform shape that was so well suited to its purpose: the builders, indeed, seem in the grouping of the openings and certainly in the vaulting to have started on that journey of strife which was to form an architecture different not only in name and form but also in idea from what had gone before.

Passing over German Romanesque as not being essentially different from Italian, the Apostles' Church at Cologne and the Cathedral of Worms being good examples, we may step at once into England and point out the beginnings of ecclesiastical architecture here. As most of our readers will begin to study by the examples around them, it has been thought best to explain such terms as are necessary in this part of the sketch as occasion arises. Ruskin once said that one could learn to distinguish the different architectural styles and the nomenclature of the art in less time than is usually devoted to the first lesson in a card game. Certainly no one need fear any dull study in order to obtain a passing knowledge of the buildings around them.

Pre-Norman Remains in England.—Firstly a word must be said about the pre-Norman remains in England. Our earliest building is of course Stonehenge, and it may be dated about 2000 B.C., but apart from it we have nothing till we come to the Celtic buildings of the seventh to the ninth century A.D. We have already remarked in the Sculpture section on the beautiful tombstones erected by these people, but unfortunately we have few buildings in any state of completeness. Ireland contains several strongholds and two wonderful monasteries in Kerry. Perhaps the most common feature of this early period was the round tower, an admirable example of which is to be seen adjoining the Cathedral of Brechin in Forfarshire.

Saxon work was far inferior to Celtic in beauty—indeed the latter can hardly be surpassed in its detail, geometric though it be, but there are many more buildings of the Latin period to excite our interest. The best known is the church at Earl's Barton with its famous tower. Others worth visiting are Wrexham, Bradford-on-Avon, Bunworth, and S. Regulus, St. Andrews. Perhaps the most noteworthy thing to observe in these is the masonry, which is of rubble with "long and short" courses. The windows are usually rounded, though sometimes triangular. It cannot be said that these ancestors of the English of the eighth to the tenth centuries were artists. The buildings are rude in the extreme, and it seems curious that they ousted so thoroughly the Roman basilicas which must have existed all over the land at the time.

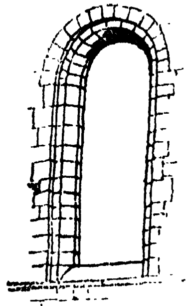
Example of Saxon Arcading

Norman Work.—With the Norman Conquest (but how far due to this it is futile to discuss) there was introduced a new style which later came to be known as Gothic architecture. But its essential spirit is to be noted in the Earlier Norman work. First, however, a few definitions may be given of the parts of the typical cathedral and church. It is usually in the form of a Latin cross. The main arm is called the nave, and in England is the westmost and central part, having on each side at least one aisle parallel to it. The eastern arm contains the choir and high altar. In England it is almost invariably square shaped, in France apsidal or rounded, often with a set of chapels or *chevet*, and it is always on a higher level than the nave, being reached by steps. The transepts are the short arms north and south between the choir and the nave, and they also frequently have aisles. On the Continent chapels abound at all extremities, and there are often double aisles wholly composed of chapels. England's great characteristic is the circular or octagonal chapter or clergy house. The nave, aisles, and choir are usually under separate roofs. The nave is higher than the aisles by two arcades: the lower one, which is blind, giving to the aisle, is the *triforium*; the upper, giving light to the church, is the *clerestory*. Various differences in the plans, such as double transepts, will be noted later, and nothing need now be said about towers. Now the chief point a beginner has to

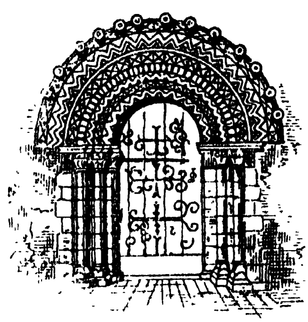
remember about a cathedral, or indeed any building, is that the architect has, apart from fulfilling the purpose of the edifice, to be ever mindful of the principles of construction. The lay mind is always a little curious about the building of a staircase, but he has to have a long acquaintance with architecture before he completely grasps the enormous problems a builder has to face.

This is not the place to go into technical details, but it must be stated at the outset that the great secret of understanding a Gothic building—and here it may be contrasted with its Roman predecessor—is to appreciate in some way that a church is an *organism* palpitating with life. Gothic architecture is based on the arch, and the purpose of the architect is to lay together, realise, and adjust all the mathematical forces which go to support the building. One must think of the stones, not as dead pieces of matter but as sensitive centres, accumulating energy now in one direction now in another; and the architect's task is to harmonise the riot. He cannot say "Peace" where there is no peace; he has to recognise every force and counteract it delicately and harmoniously. The arch has one part to play, the pillar or column another; the ribs of the roof catch and disperse the forces overhead and guide them downward; the *buttresses* or outside piers counteract the enormous lateral movement, and the turrets on the top of them keep them in their place. The transepts relieve the accumulated force of the nave, the towers at different points are all brought into concrete action, and last but not least, when openings are wide and the walls thus weakened, the flying buttresses rise up aerially and counteract the stress. A church indeed is a thing of beauty, but it is not that alone—the mind of the artist has been at work, and woe betide his structure if his knowledge is unsound. Keeping these points in mind, we shall find that the history of architecture shows no arbitrary change of tastes, but rather the development and evolution of man's mind—loving, on the one hand, to prove its constructional ingenuity and on the other its taste for pure ornament.

In the examples that remain to us of the Norman period we see the beginnings of Gothic aspiration. The chief characteristics are those of all early work. Its main feature, of course, is the semi-circular arch, either alone or in groups, and in later work intertwined. The pillars of the arch are short and very massive: the capital, of a square cushion shape, is very noticeable. The doorways are beautifully enriched with the well-known zigzag ornament. Walls are very thick, and the mortar-work is usually of inferior quality. The whole appearance of the buildings is massive. Timber roofs are frequently used, but sometimes the vaults are of a waggon or barrel type. Towers are square and of great mass, often with blind arcades and parapets. The best early example we have of the style is the St. John's Chapel in the Tower of London. The height of the triforium in it is characteristic of the time, and the apsidal

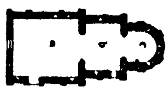


Norman Window



Norman Doorway

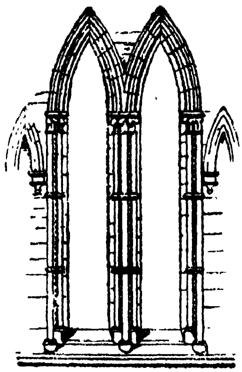
end connects it with continental buildings. Most of our cathedrals are of this period, though they have undergone many changes since. Durham and Oxford are perhaps most complete, the nave of the former showing greater variety than, say, St. Albans or Norwich. But examples especially of small churches are to be met with all over England and Scotland, a good Scotch church being that of Leuchars in Fife. They are all easily recognisable for the characteristics mentioned. The period lasts from 1066 to 1170.



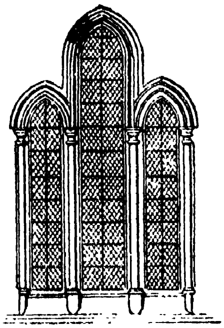
Plan of Norman Church

Gothic Architecture in Britain.—With the coming of the pointed as distinguished from the rounded arch, Gothic architecture in the strict sense begins, and England was as early in the field as any country with what is called the *Early English style*. Discussions as to the origin of this arch are quite unnecessary. It is sufficient to state that the problem of vaulting, introducing as it did at its diagonals arches of different diameters and the interlacing of the semi-circular arches, showed the way, and the typical ecclesiastical form which has so fully embodied the aspiring ideal was the outcome. Builders came to learn that massiveness was not the only quality in judging the strength of a support, but for a time we find, as was natural, both types of arch used in the same building. Again, much has been written on the French origin of the English style illustrated by Westminster Abbey, but whatever truth there is in this it may be at once observed for those who are patriotically inclined that English Gothic developed in its own way, with peculiarities unknown across the Channel or anywhere else. Lincoln's choir shows the earliest work, but the best illustration of the ideals of the early thir-

teenth century is the cathedral of Salisbury, a building as beautiful from a constructional and artistic point of view as any other of any time or place. Apart from the lancet shape of the openings perhaps the most noticeable trait of the style is the more slender size of the columns and the "dog tooth" ornament which



Early English Lancet Window

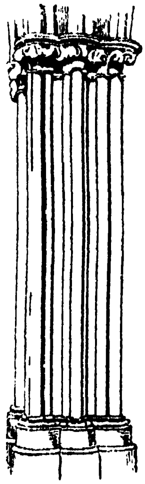


Early English Window

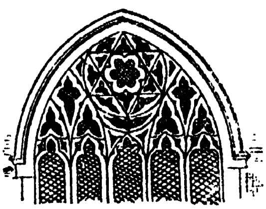
is not found on the Continent. This is carved by a chisel instead of the axe of the Norman period. The famous Five Sisters in the transept at York Minster so beautifully grouped are of this period, and quite comparable with them are the ruined east ends of Tynemouth Abbey and Elgin Cathedral, the well-known nine altars at Fountains Abbey, and the nine altars of Durham.

This grouping of the lancet windows in detail and as a whole is what we may justly term English in its delicacy of execution and beauty of proportion, and we miss such a treatment at Chartres and Amiens, wonderful as these are on account of other qualities. There is no exaggeration, no false simplicity, but a restrained harmony that gives a most completely artistic delight to the beholder. If anything were needed to intensify the pleasure of such a one, it was colour, and this was supplied in wondrous wise by the thirteenth-century stained glass. Unfortunately we have little of this in England, but York still retains for our admiration—though much bespoiled by later glaziers and their patterns made unrecognisable—the early grisaille or silver-coloured glass in the Five Sisters. Still better grisaille, though not in nearly so impressive a position, is to be found at Salisbury, and at Canterbury there are some medallion coloured windows of beautiful hues. More will be said about this medium later. Of west ends no more lovely examples could be found than the porch at Ely, which is a perfect gem of design. It is to be noted that the usual English west front is far less elaborate than in France, yet of this period we have two of the richest, Lincoln and Wells. The former cannot pass the test of Ruskin's *Lamp of Truth*, it being a first principle of construction that there should be no shame on the face of a building to tell how it has been built. Wells, on the other hand, disfigured as it is by later additions and over-adorned, is one of excellent proportion and design. An attempt is made to roof by means of vaults oblong and not square compartments. To sum up the chief characteristics of this period, which lasted till the end of the thirteenth century, we observe simplicity but delicate purity of execution, and a firm grasp of proportion as the essence of architectural beauty.

In the earliest pointed period two lancet windows were often grouped together, and the space above or *tympani* had been pierced, giving what is called *plate tracery*. As time went on, however, greater elaboration was attempted, and the stone-work between the lancets itself was made as slender as possible, becoming a *mullion*, and the upper part above the heads of the lancets was *cusped* with geometrical designs. The buttresses with the increased size of the windows become more important, and the ornamentation in every place in capital or cornice is more naturalistic. A very beautiful feature of the style is the clustering pillars, several slender shafts surrounding a central column. At first geometric (*trefoil, quatrefoil,* &c.) designs were most popular, but later, with greater mastery of the constructional schemes, more daring and flowing tracery was adopted. To this period belong those wonderfully compact chapels and chapter houses which are so beautiful a feature of the English style. As good an example as any is St. Etheldreda's Chapel in Holborn, now restored to the Roman Catholic Church, where the east and west windows show elaborate work at its best. The vaulting now becomes more complex, and lierne ribs, *i.e.* those unconnected directly with a support, appear and provide the artist with stuff for his chisel. Merton College

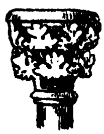


Clustered Column Wells



Decorated Window

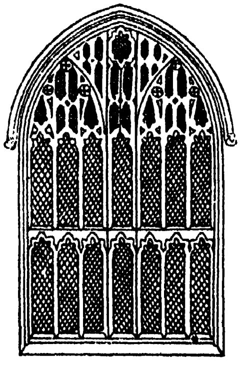
Decorated Pinnacle



Decorated Capital

Chapel and the Lady Chapel at Ely also show beautiful work, but it is probably in the chapter houses that the skill of the English architects is best to be seen, and of conspicuous merit are those at Salisbury, Westminster, Wells, and York. They give great opportunity for displaying nicety of proportions and charm of decoration. But it must not be thought that the most beautiful work of the time is only of small dimensions. The nave of York, the nave and choir of Exeter, and nearly the whole of Lichfield and the choir of Carlisle are all of the *Decorated Style* which flourished in the fourteenth century. Exeter especially ought to be visited to appreciate the beauties already named in roofing, tracery, and column, and the proportions of Lichfield are even more satisfactory.

Perpendicular Style.—Towards the end of the fourteenth century in England, as on the Continent, the imagination of the architect began to run riot, and what is called the *Perpendicular Style*, so much abused by Ruskin, came into being. Though peculiarly natural in detail, it is simply an extension of the tendency from simple to complex that we see in all the architecture of the time. The ideas of the architects and builders could not be restrained by mere geometrical designs. They first naturalised the ornament and then made the whole building an excuse for showing their ingenuity and daring. Ornament grows in wild profusion everywhere like weeds. Any part of a building formerly necessary and now rendered unnecessary because of greater mechanical skill remains in order to have placed upon it some ornamental device. The simple building of earlier times,


Perpendicular Window


Perpendicular Niche

showing its construction on its face, completely and artistically fulfilling its purpose, gives place to a building that deceives the eye at every turn if only it shows the taste of the day. Everything solid is tapered down, ornamented, or panelled so that no suggestion of heaviness may remain. Churches are carved in the form of a lyric at the great expense of artistic truth. Pillars become mere wisps of stone; but windows on the other hand increase to such a size that there emerges only a wall of glass. But miracles of ingenuity result. In England we have no flights of engineering such as at Beauvais, but the roofing attains a hitherto unknown architectural and artistic importance.

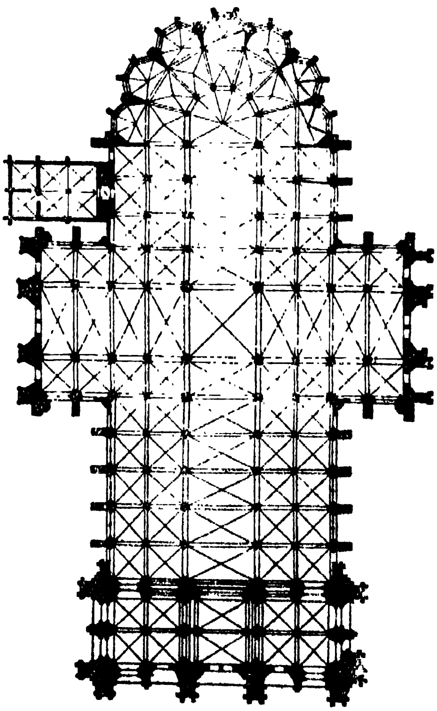
In detail the chief changes to be observed are the tracery of the windows giving the name to the style. Their mullions have a decidedly perpendicular effect, and it is interesting in different examples to notice the gradual change from the older geometrical designs to the later flamboyancy. There is also a tendency to split the windows into compartments rendered necessary by the huge area covered. The arches, again, are much more square or "dumpy" in appearance, often of the "ogee" shape, and with a square moulding over the top, the spandrel being filled in. The typical column consists of four shafts of the same great height as in the preceding style, but the carving of the capitals is much more conventional, though not in England tending so much to the Corinthian acanthus shape as on the Continent. One feels, however, the absence of that loving intimacy with the natural objects represented, or even the delicate if homely beauty of the expressions, which are so marked features of thirteenth-century work. The roofs are marvels of cleverness, as for example the famous fan vaulting of Henry VI's Chapel, St. George's Chapel, Windsor, and King's College Chapel, Cambridge. This is a unique characteristic of the English Perpendicular style, and if it is formed at the expense of truth and restful simplicity its daring is accompanied by real beauty of exquisite ornamentation and in the chapels referred to crowns the adventure. It is the "looping the loop" of architecture, wholly justified by success. The many accessories of a cathedral, such as canopies, choir stalls, screens, and fonts, of this time are specially numerous. The stained glass ceases to serve its purpose as a light-giving agent, and becomes an excuse, and a very bad one, for the painter's leaving his last. He tries to ignore his material, and uses glass as if it were canvas, never having learnt that its very conventions, if rightly regarded, are the main source of its beauty.

An interesting difference is seen in most of the Scottish churches of this period. The Perpendicular style is seen in very few examples, but foreign influences—mostly French—are far more observable. This is especially so in the window tracery which often, as seen well in King's College Chapel, Aberdeen, takes on a pear shape. A large central mullion is a curious feature of these windows. Melrose Abbey, Elgin and Aberdeen Cathedrals among others show foreign influence. The little Chapel of Roslyn near Edinburgh owes its inspiration to Portugal—not, however, with really artistic result.

Gothic Architecture in Other Countries.—Having grasped the essentials of Gothic architecture in our own country we may look at the Continent and note how the same principles have been worked out there. We find less difference than ought to be expected, chiefly owing to the fact that there was such an intimate relation between the different branches of the Church wherever situated, and more so the omnipresence of the same monastic communities. France as the home of the new change deserves first mention, and indeed when the student has become acquainted with his country's buildings no more enjoyable task can be set him than to take a tour or tours to the cathedrals and churches of France. Here he will find the same development as at home—first the exit from Romanesque, secondly the fully developed style, thirdly the flamboyant mistakes. And in France above all places he will find constructional problems at the root of all the changes. The Abbey Church of St. Denis near Paris, begun in 1140, shows the change commencing, for though it retains Norman characteristics in its round arches its plan and manner belongs to the later style. Close on its heels were built the great cathedrals of Notre Dame de Paris, Chartres, and Laon. Probably Notre Dame will be the first French cathedral visited by the Englishman, and though not nearly so exquisite an edifice as, say, Chartres or Amiens, it will prove at once to him the difference in taste of the English and French schools. It could never be mistaken for an Early English building even without its later additions. The west façade attracts at once; the flying buttresses, the curious lengths and heights of the nave, triforium, transepts, and chevet, the wonderful rose windows, all give it what it really must have, a very foreign look. Similar to it is Laon Cathedral, but it is far outclassed by the Cathedral of Chartres, for many reasons the noblest church of the Gothic style. It is easily visited from Paris, and should be early studied. The general impression is one of great simplicity and rest, caused to a great extent by the beautiful proportions of the towers and spires, so harmoniously are they designed. The sculptures are mentioned in another article; they adorn a west front and north and south porches of exceeding merit; the early stained glass—the most beautiful in the world—completes perfectly this religious building. One has only to be present at one of the fêtes to be transported to an ideal French atmosphere, a community in joyful worship.

Beautiful as Rheims Cathedral is—and it resembles in many respects Chartres—Amiens represents French Gothic at its best developed point. The structural problems of height and breadth which so much involved French architects are here solved with artistic accuracy. Sculpture is again prominent, but it is in the interior that we get the most impressive idea of the building. A far greater feeling of vastness is obtained by its beautiful proportions than in larger cathedrals; the position of the windows makes it more "open" a Bible than any other—a result that is greatly intensified by the simplicity of its vaulted roof. It is, in short, worthy of all the adulation given to it by Walter Pater and Ruskin, even apart from what is often considered its chief glory, the rich carving in the choir. In Beauvais Cathedral the architects reached their downfall; built to show that there were no limitations to the law of support, the choir vaulting fell before the church was completed. Of the later buildings the two cathedrals at Rouen are the best specimens. They show work of all the different periods, and thus lose the harmony of the earlier work, but from a student's point of view they are all the more interesting. In these and other cathedrals and in such churches as the Sainte Chapelle of Paris, the Abbey of S. Michel, S. Pierre, Caen, and S. Maclou, Rouen, the details especially of the carving and tracery should be compared with English contemporary work. In the later churches in the flamboyant style one will notice the absence of our Perpendicular features.

In Italy a very different style was evolved, owing to the fact that Roman influences were



Plan of Cologne Cathedral

never really ousted by Gothic principles, and no such development as we have noted in England

and France takes place. Milan Cathedral at once shows the difference. Its chief merit is its size, and the expensive stonework. Further south, Florence Cathedral is noteworthy for the famous Campanile of Giotto and its dome, which is its great glory. It is to be observed that brickwork faced with marble is nearly always used, and this is probably one of the main causes of the difference in style. The Frari Church in Florence is a good example of Native Gothic in its purest manner. Spain is even less interesting as showing natural characteristics of the period. Most of her cathedrals owe what inspiration they have to the French. The dome is a feature of the cathedrals at Zamora, Tarragona and Salamanca, and the famous towers of Burgos with their rich ornamentation are interesting, and Seville is the largest Gothic cathedral in the world, but the ecclesiastical architecture of this country is chiefly remarkable for the Moorish characteristics to be afterwards mentioned. In Germany the deservedly famous Cathedral of Cologne, though it was completed only in the last century, requires to be noted. Its plan is specially good. Its towers and spires are very effective, and the long nave with its outside row of chapels making at the apse a beautiful chevet, are its chief features. Other cathedrals claiming attention are those of Strasburg—of early date —Freiburg and Ulm.

Domestic Gothic Architecture.—Very little need be said of the non-ecclesiastical buildings of this period. Only the stronger castles of the day have survived, and these are very rarely in their original state. When they do so they exhibit in their arches and pillars all the characteristics of the date in which they were built. In England the chief early example is the Tower of London with its very simple plan and unmistakably Norman characters. Later you have the moats, outer and inner courts, and dining halls, and gradually the modifying of the military features and consequent increase in the domestic apartments. A very good building to study is Kenilworth Castle, which, originally built in the early twelfth century, has well-defined additions till the end of the sixteenth century: other well-known buildings are Penshurst Place, Kent, Westminster and Crosby Halls, London, Cranbourne Manor, Dorset. Timber buildings of both early and late style are best seen at Chester. In Scotland as in England, there are several old Norman towers or keeps in more or less interesting states of preservation, and the circular tower to be developed in Renaissance times comes into being during the Gothic period. The crow-stepped gable of the "lands" in the old houses in Edinburgh, along with their great height, and planned as they are round a courtyard, shows the same French influence observed in the churches.

Up and down France and Belgium, especially in the old towns, one meets houses, even streets, of great beauty. That of Jacques Cœur in Bourges shows beautiful details in its window and wall tracery of the fifteenth century, and the Palais de Justice, Rouen, is the best municipal building of about the same date. It fits in appropriately with the street architecture of this noble French town, which, along with its two wonderful cathedrals, make it, apart from Venice, perhaps the most interesting architectural city in Europe. The Hotel de Cluny in Paris will not be passed by, by lovers of the "Bou Mich."

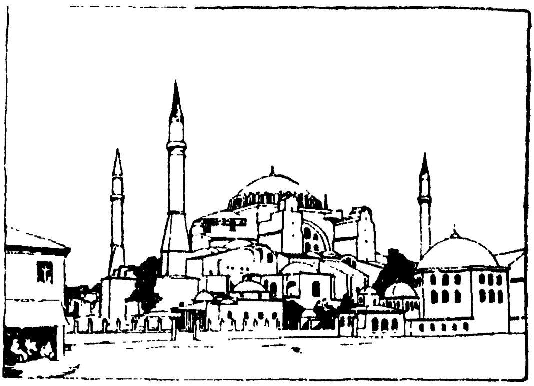
The history of Belgium is that of gallant municipal endeavour, and it is sufficiently expressed in architecture, especially in its town halls. Of a peculiar style, rectangular in plan, and several stories high, with their simply decorated front, steep roofs, and high tower or belfry exquisitely if a little curiously proportioned, from the point of view of anyone who takes a non-German view of culture (and it is for those that this is written) they yield to none in æsthetic interest. Nearly every community has one or more of these halls, but specially remarkable are (or were) those at Bruges, Louvain, Brussels, Ypres, Ghent, and Liège. In the houses the crow-stepped gables and dormer windows are exceedingly picturesque.

In Italy the Florentine domestic buildings yield in importance to their Renaissance successors if we miss out the Palazzo Vecchio and the Loggia dei Lanzi of the thirteenth and fourteenth centuries respectively. The tower of the former is as interesting as it is well known. But when we move to Venice the earlier period assumes the same excellence as in ecclesiastical work. Venice is, in spite of its conventional lovers, still a city completely wonderful and beautiful. The palaces, whether still in their former glory or used as dilapidated warehouses, in the Grand Canal or in some small, evil-smelling waterway, still claim our unbounded admiration. And they belong to nearly every period. The earlier Romanesque buildings are interlinked with Byzantine details, the fully developed Gothic style of the fifteenth century typified by the Doge's Palace abounds everywhere, a Renaissance work of every sort jars or pleases one, as the case may be, at every turn. Of twelfth century work, the Palazzi Loredan and Farsetti, now used as the Municipal Offices, and the Ca' da Mosto are good examples, though restored in parts. They are simple in design, but fascinating in their fresh primitiveness. Byzantine influences are well marked in the Palazzi Sicher, and Laibante, and Businelli, the windows of the last-named being noteworthy. Of the Doge's Palace manner there are very many good buildings, notably the Palazzi Gunstani and Foscari, which stand together on the Grand Canal; but the most famous palace of this style is the Ca D'oro. Small in bulk but exquisite

in detail, this gem of architecture, defaced though it has been, still epitomises the joyful exuberance of Venice. In any other city it would look gaudy, and its exterior was once gilded; here it fits in most beautifully with the sky and the water. Its three arcades of gorgeously carved pillars are relieved by the simplicity of the further side of the building. But the Palace itself now claims our attention. Its fifteenth century work has undergone various restorations, but it still remains the most beautiful domestic building in the world. It consists of three divisions; a wide arcade below supports a gallery above, which is surmounted by a much higher story of pink and white marble in lozenge shape. The sculptures are dealt with elsewhere. The proportions are curious and at first puzzling. The lower arcade seems, in spite of the massive pillars, to be top-heavy, partly due to the raising of the pavement of the Piazzetta which it adjoins. But this adds perhaps to the variety. The upper gallery, with its quatrefoil spandrels and ogee-shaped arches, is the most richly decorated part of the building, while the walls above prove a very effective and simple setting to the profuse decoration beneath. The architect in this has transposed the ordinary architectural tradition, but to the present writer at least the result is altogether satisfactory, the marble facing of the wall giving sufficient relief to an otherwise heavy treatment. This part is pierced by two balconied windows, one to each façade.

Byzantine Architecture.—Everyone knows vaguely that the capital of the Roman Empire was shifted in A.D. 323 by Constantine to Constantinople in the old Greek colony of Byzantium. The architecture we now discuss is the style developed there and at other places under its influence. Constructionally, even in its advanced form, the style did not differ from its predecessor. Superficially we note first of all the absence of the orders with their pediments, and in their place as most noticeable a beautiful grouping of domes. The walls are made with concrete, but mortar-bound brick has a greater place, being in the later forms used with great ornamental effect. But there is no advance to the Gothic solutions of stress. The interiors are covered with mosaics and other decorations, and faced marble is used extensively, both outside and inside. The chief Byzantine church is that of Santa Sophia at Constantinople, erected in the beginning of the sixth century. It is now, of course, converted to Mohammedan uses—whether temporarily or permanently it is not at the present moment wise to say. In plan there is a central space covered by semicircular arches supporting the great dome. Around this are grouped entrance porches and other chambers, all dome vaulted. A prominent feature is the number of galleries. The simplicity of the interior is counteracted by the exuberant wealth of colour produced by the marble arches, mosaics, and hanging lamps.

Nearer at hand, and more familiar to the English traveller, is the famous St. Mark's, Venice. To the western eye at first sight this church, which is not much debased by Gothic additions, looks garish, but closer observation removes the impression. No building in the world so well typifies the ideals and history of its surroundings. It was built for the most part in the late eleventh century after a Constantinople



S. Sophia, Constantinople

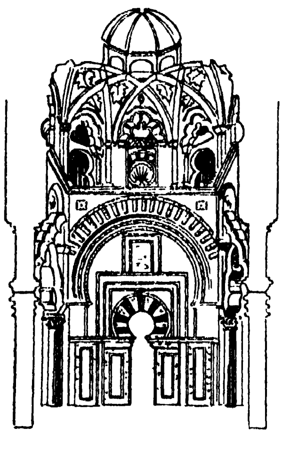
model, in the shape of a Greek cross covered by domes. The wealth of colour detracts from any great idea of space, but it has other attractions. Nowhere else can mosaic in its best form be studied, and the early examples here are themselves worthy of a prolonged visit to Venice. It is sufficient to note that they carry out in the most delicate manner the modern artistic truth that conventions, when observed with respect and not despised, add so much to the beauty of the general impression that they oust verisimilitude from its chief place as a factor in art. In early mosaic work art is quite unembarrassed by Nature. The different examples of marble and other stones used provoke a comparison. In the *Italian Gothic* a general monotony is produced by the unskilful way in which the exteriors are faced with chess-board varieties of colour. If you have a small acquaintance with different stones you will recognise at once on the western entrance to St. Mark's up to a dozen different marbles. Especially if uncoated by dirt (these pillars are cleaned every few years) the different grains catch the eye at once, producing the necessary complexity or intensity of view. In the ordinary Italian façade the eye takes the whole pattern in at a glance; in any of the sides of St. Mark's a far more varied, what might be called musical, harmony is achieved. The gaudy impression is given wholly by bad mosaic work and late additions. There is a world of difference between richness of colour and tawdriness. No

reader of Ruskin will overlook the exquisite carving in the incised capitals and some of the sculpture, so delicately and artistically do they represent the outlook of the tenth and eleventh centuries on Nature.

In St. Vitale, Ravenna, Byzantine influences are very marked, while the Londoner will get a fair idea of the style in the new Westminster Cathedral.

Moorish Architecture in Spain.—As has been previously noted, no attempt is here made to sketch Saracenic architecture in Egypt and Syria, but travellers in Spain would rightly take it amiss if no mention were made of the wonderful style of the Moorish or Arabic remains in Andalusia. These belong to a period as extensive as from the eighth to the fourteenth centuries, but it is a commonplace to say that in a country the most national in the world every branch of thought or sphere of life has been touched by the existing facts, and most beautifully so. All these delightful belfries we pass in the town or country of Southern Spain owe as much to the East as the skin of the most popular bull-fighters, but apart from that there are wonderful buildings not much corrupted by the antagonistic forces of the West.

Earliest in date (A.D. 786) is the mosque at Cordova, now the cathedral, originally second



Section of Mosque at Cordova

only to Mecca in importance. Instead of the Christian four aisles we have nineteen, and the general impression as one enters is that of a forest of low (30 feet) pillars. Looking at them closely an extraordinary tale is told, for you will find original Roman Corinthian pillars standing cheek by jowl with Greek, Arabic, and Byzantine columns. The arches are of the proverbial horseshoe variety, and originally it is to be remembered no outside walls existed. The chief Mihrab or praying tower is specially beautiful, the walls being, as always in this style, covered with richly coloured stucco in the form of texts from the Koran, no natural representation in ornament being allowed. The central part is architecturally and needlessly deformed to the use of the church, and there is a considerable amount of imitation work. The Court of the Oranges outside, the exterior of the tower, and the doors are less important than in the other buildings now to be named.

The Alcazar or King's Palace at Seville is a small edition (thirteenth century) of the Alhambra, though many admire it more. It is sufficient to say that in the original doors, stalactite roofing, and wall ornamentation the visitor will find perfect æsthetic delight, and his western eye will receive a shock in the glow of the colours. The Giralda, which is the old tower of the Gothic cathedral, is the most perfect specimen of exterior Saracenic work of the kind. From the inside, up which you climb without the use of steps, you can study its exquisite geometrical ornamentation. In the view of the present writer it is, even apart from some later additions, in its proportions, decoration, and general effect the most beautiful tower in Europe. Its height is 275 feet, and except for the belfry was built in the late twelfth century.

The Alhambra at Granada, of the fourteenth century, is the most famous building or group of buildings of the style, and it contains in itself perfect specimens of all the peculiarities of it. To begin with, its general situation, its courts, gardens, and fountains make this king's palace a veritable castle in Spain. The woodwork of the doors, so rich in its carving, the glory of the walls with their blue and gold stucco decoration above and tiling below (the lustre examples are specially fine), the peculiar pillars and capitals, the Moorish arches, the stalactite roofs, the joyous glamour of the vegetation, are summed up only by the sense, so subtly felt yet omnipresent, of pure running water. It is indeed an Arabian dream of beauty and wonder.

Renaissance Architecture.—As this sketch is meant for the untutored, it may be well at the outset, even at the risk of repetition, to state the differing principles of Gothic and Renaissance architecture. When travelling abroad one is universally met with a pathetic question, not confined to American pork-butchers nor anæmic girls, "Now this is Gothic, isn't it?" The distinction is fundamental. In the twentieth century, when an architect sends in his plans of a church for competition, he in many cases has to decide what style he is to adopt. No such choice occurred to his ancestors. Architecture is a living expression of the age. The architects of Chartres or Salisbury were not trained in the history of architecture, the style was in the atmosphere surrounding them; out of this their genius created a work of art. We have seen in the case of painting and sculpture how the Renaissance worked. True the

artists imitated ancient models such as they knew them, but even in their errors they gave vent to their point of view. And some reaction from the Gothic ideals of the fifteenth century was necessary. We have remarked how flamboyant or decadent the architecture of that time was—many different aspects of life joined together to make the change. The Gothic church fulfilled the ideals of the Christian worshippers as a whole; we now in the sixteenth century are more concerned with secular nobles —we see fewer examples of churches and more examples of palaces. In the churches themselves we seem to lose hold of that individual interest in each detail of the work that typifies so well the contribution each citizen (and they were all churchmen) made to the religious faith. More concretely, the chief changes are these. The early classical styles—Doric, Ionian, and Corinthian—with their columns and entablatures and semi-circled arch, emerge. The dome takes the place of the tower. The vaulting is Roman without ribs. Instead of a dazzling complicated harmony of antagonistic lines there is a severe simplicity of conventional and geometrical form, the general impression being horizontal instead of perpendicular. The walls of stone—or, as was very common, marble —are smooth, affording little or no play of light and shade. Above all else, perfection is sought and attained by elimination of all conflicting lines. We have noticed that the essence of a Gothic building is the battling of forces; the ideal is fought for, and being high, cannot be reached; in the Renaissance building all is sacrificed to an uninterrupted impression of proportion.

Italy must have first place, and Florence was the home of the movement. Most of the sculptors of the day were also architects—Della Robbia, Ghiberti, Donatello, Mino and Benedetto. But in Florence the "duomo" puts everything else in the shade, and Brunelleschi is its famous designer. However little Florence Cathedral may impress one apart from the Campanile and the Baptistery—and the conventional symmetry of its marble facing and ignorance of the wonderful stained glass are the main factors in this—the dome itself must always rank as a brave and beautiful work. The Pitti and Riccardi Palaces by Brunelleschi and Michelozzo are as good examples as any of the heavy strongholds of the Renaissance nobleman. The atmosphere of modern Florence is always rather depressing in spite of the host of artistic gems in it and the kindliness of its people, and these palaces are there not out of place. The churches of St. Spirito and San Lorenzo are worthy of attention. In Rome the most famous palace is that of the Farnese. In all these palaces special note should be taken of the different plans, the orders in the façades, the presence or absence of square or round-headed windows, the exquisite ornamentation of brackets, &c. Given the cramped medium, it must be admitted that the architects evolved very dignified and symmetrical work. To most people the Renaissance is synonymous with St. Peter's, Rome, and St. Paul's, London. St. Peter's had a very chequered career. The chief names to be remembered with it are Baamanto and Michel Angelo. The former designed the dome, which was subsequently altered by the latter, to whom most of the plan is due, but who died before the cathedral was built, and in turn had his designs upset by successors. The chief additions are the façade and the colonnade of the Piazza. The Corinthian columns both inside and outside will fix this style in the student's memory. The walls of the interior, like those of many Scotch churches, are of painted plaster; but on the whole the desired effect of grandeur, dignity, and harmony is fully attained.

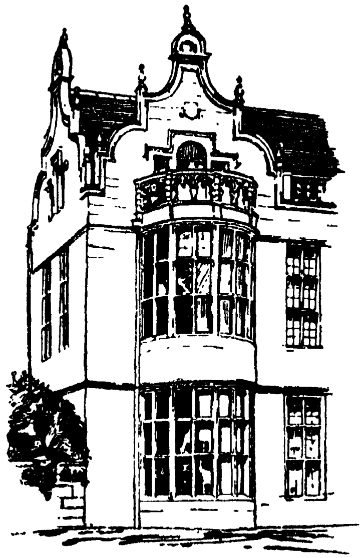
Compared with earlier work the Renaissance palaces in Venice have less of that typically joyous note which is so marked a feature of this most beautiful of cities. In point of fact one usually ignores them, but they have peculiarities of their own which are very interesting to the student. The Vendramini and the Pesaro Palaces are best known, but noteworthy features of nearly all of them are the grouping of the windows, the balconies, and the ornamentation of the churches. S. Maria della Salute owes its splendour to its position and grouping. The courtyard of the Doge's Palace is as unhappy as St. Mark's Library is completely happy. Both are by Sansovino. The Library is worthy of minute inspection, its proportions being perfect. The architect of St. Giorgio Maggiori, Palladio, is better seen in his native town of Vicenza, where the Palazzo del Consiglio with its double series of arcades cannot be over-praised. The Palladian style, simple, even severe but practical, is the foundation of a lot of what is best in English Renaissance work.

France, in adopting the spirit of the age, was reluctant to dispense wholly with the Gothic style which had proved so faithful a servant in earlier days. Thus with good but ineffective intention she strove to combine the two, often with most incongruous effect. The transition stage is best worked out in the châteaux of the Loire, and of these the Château de Chambord is rightly the most famous. The circular towers and the dormer windows are noticeable remnants of the earlier times. The Château de Blois with its famous spiral François Premier staircase and the Château de Chenonceaux are other well-known examples. In Paris of secular buildings we have the Louvre and the Tuileries (which shows in itself the progress of the style down to the middle of the nineteenth century), the Luxembourg, and Versailles, the last of which is as ineffective outside as within. Of churches

St. Eustache and St. Etienne-du-Mont show the transition feeling, and one would say represent the French spirit as few other churches in Paris do. No one will overlook the double staircase in the latter church. Close at hand is the Pantheon by Soufflot, of the eighteenth century—a most admirable Renaissance building. The Invalides Dome and the Madeleine, the latter of the nineteenth century but a good copy of Roman work, are also noticeable. The Palais Royal and the Sorbonne do not add much to one's architectural knowledge.

Germany copied French absurdities and incongruities, but rarely escaped the dumpiness that is so characteristic of the nation. The Pillerhaus, Nuremburg, and the Cloth Hall at Brunswick most successfully, perhaps, escape the general lack of delicacy. Belgium, on the other hand, shows in many specimens of street architecture a quaintness quite unalloyed with gross detail, and the Antwerp Town Hall shows a most interesting adaptation of Renaissance orders and ornament to practical purposes. Spanish attempts to conceal the passion and splendour of her aims in a dead language could not be of much beauty. The town hall in Seville is imposing and rich in detail, and Charles V's Palace at Granada is Italian in spirit, but the well-known Escorial near Madrid, with its different buildings, is the greatest monument of this period in Spain, both in its plan and execution.

curious buildings. Holland House and Hatfield House are the best known. Curiously shaped chimneys are a feature of these buildings, porticos, and arcades are common, and the classical orders are used indiscriminately.



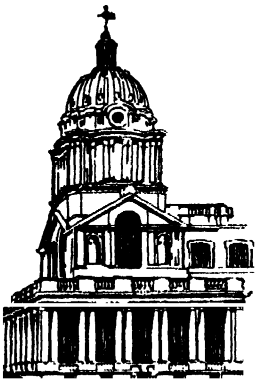
English Renaissance. Lilford Hall, Northants, 1635. (Gotch).

Renaissance Architecture in England.—The architecture of the Renaissance in England is interesting nearly as much for its mistakes as for its success. It is to a great extent the history of the English country house. After Henry VIII's death in 1509 there seemed to creep in a catholicity of taste equalled only by its ignorance. The result was a welter of antagonistic forces. Most of the Tudor chaos, as it has been well called, is due to the free hand given to barbarous German architects or workmen. Whenever we find Italian, French or Belgian influences gaining we get no small delicacy and refinement of taste ornamenting the native love of practical usefulness. When German ideas predominate all is gross and furthermore dull. In the Elizabethan, which is the first of the Renaissance styles (1558–1603), we have Wollaton Hall, Kirby Hall, and Knowle House. In all the hall, staircase, and upper gallery are the chief features. Several parts of Oxford and Cambridge colleges, too, belong to this time. But though the country house is the English equivalent of the Florentine palace, some of our town houses, especially the easily recognisable half-timber ones of Chester and London, have a delicate charm of their own. *The Jacobean Style* (1603–1625) continued the incongruity. Special mention must be made of the formal terraces and gardens which surrounded their

But it is to Scotland that we have to pass for artistic buildings of the sixteenth century. The so-called baronial castles of the day, well known for the pepper-box turrets, prove to us that even at this comparatively late date dour Puritanism had not quite eliminated æsthetic feeling. Founding their architecture on the French, with whom they were so friendly, they developed a style of their own which for beauty of design and excellence of adaptation of means to end is unsurpassed. The best-known examples are Bothwell, Crichton, Cawdor, Craigmillar, Linlithgow, Fyvie, and Holyrood.

With Inigo Jones we take a step to a clearer appreciation of the aims of the Florentines. His best work is seen in Greenwich Hospital, St. Paul's, Covent Garden, and the Banqueting House, Whitehall, part only of a wonderful palace designed but never executed by him. It was he who first introduced the art of Palladio to England, and Inigo Jones had lovingly studied at Vicenza and Venice those buildings we have already mentioned. If St. Mary's Porch, Oxford, and Heriot's Hospital, Edinburgh, are truly his, they simply show early work. His name cannot be too much held in honour in our architectural history. He understood his material and the style he worked in—above all he cleaned out German weeds which so hampered the development of an English Renaissance style.

Probably Sir Christopher Wren is the only architect whose name is known to the man in the street. The Fire of London in 1666 gave him an opportunity of town-planning such as few men have ever had, but as is always the case, he was not allowed a free hand. In fact one of his chief merits (and it is in architecture one of the first class) is his adaptation of buildings to cramped surroundings. Passing over some work in Oxford, we come to the London churches and St. Paul's. The former are as well worthy of attention as any Renaissance buildings. The true spirit of the day gave this mathe-



Portion of Greenwich Hospital

matician boundless opportunities for exercising his constructional ingenuity, but over all he has super-imposed effects of great dignity and simplicity. St. Stephen's, Walbrook, is justly famed for these qualities, and nothing is more characteristic of the City church than the Bow and St. Bride's churches. Other works of his are the dome of Greenwich Hospital, the Monument, and the old Temple Bar. St. Paul's as we see it now was not Wren's first design for the cathedral, but it is undoubtedly his best. Especially externally, viewed close at hand or from Ludgate Hill, or taking the magnificent dome by itself, it must be pronounced the most successful Renaissance building on a large scale in Europe. His undoubted practical qualities are given full play in the East of Hampton Court, which was rebuilt by him. And here in a new material—brick dressed with stone—he shows to great æsthetic advantage. The Tom Tower at Oxford must not be ignored among his minor work.

After Wren's death his followers, in their attempts to imitate Palladio and others, seemed to have quite overlooked what may be called "reason" in architecture. Any little nook or cranny in a house inside or outside was made the excuse of so-called classical ornament. This movement is, of course, at once comparable with its sister art of literature in the "Georgian era," but even Pope could see the faults in architecture when it interfered with his comfort even if he ignored the analogy in his own art. Kent, Gibbs, and Chambers (of Somerset House fame), are the least bad. Vanbrugh is nearly always ugly. It is refreshing to find genuine practical Renaissance ideas in the buildings of the brothers Adam, who are best known for their interior ceilings and chimney-pieces. Few towns in any country can show such really beautiful work as the Register House and the north side of Charlotte Square, Edinburgh. These are far better than the larger old University Buildings.

Modern British Architecture.—The Classical Revival of an archæological architecture was succeeded by the Gothic Revival of the second half of the nineteenth century. A late offshoot of the literary movement named the Romantic Revival, and giving expression to the ideals of Oxford Puseyism, its chief herald of course was Ruskin. The results were various. Firstly, a much finer appreciation of the Gothic work of the Middle Ages: secondly numerous mistakes in restoration: thirdly, gross copyism of Gothic details without the spirit and workmanship of the old guildsmen. The Houses of Parliament, Westminster, are the firstfruits of the movement, to be followed by the imitation series of earlier work by Sir Gilbert Scott and his friends. At its best, say in St. Mary's Cathedral, Edinburgh, you get negative correct qualities of various kinds degenerating into dullness, along with certain beauties of stonework. But over all there is the sense that the building is a mere exercise in mimicry, freedom, and variety, that delight which usually developed into humorous touches and is so inseparable from the Roman Catholics churches abroad. And when freedom was shown it usually took the form of Street's Law Courts or Waterhouse's Insurance Offices. Here and there, however, up and down the country one does find Gothic churches which show a brain behind that will not be hampered by the mere littles of a style: who, if he is unable to get workers to carry out the spirit of the olden days, attempts a new formula which they may understand. For architecture, as must be repeated, is the expression of men's adaptation of means to an end. Our wants create the end; the artist cannot satisfy them with a scholastic study totally divorced from surrounding circumstances. By this test even so fine a building as St. George's Hall, Liverpool, by Elmes must fail. Notice must be taken of the work of J. G. Jackson at Oxford, Basil Champeys there, Cambridge, and Manchester, and Sir Rowand Anderson at Edinburgh. These men, while clinging to the older ways, do not become garrulous. The leader of modern English architecture was the late Norman Shaw, and he has founded a school

which is doing important and beautiful work in all our chief cities. He made it his business to learn the beautiful features of Continental domestic architecture, and from those he seems to have sifted out those which would best suit our English atmosphere. The result is a truly individual style, anything but grotesque, refined in feeling, rich in detail, always adapted to its purpose. His chief buildings are the Gaiety Theatre, the Piccadilly Hotel, and the Alliance Assurance Office, all in London. His development is seen from the New Zealand Chambers, Leadenhall Street, and New Scotland Yard, both from his hand. He and his followers or colleagues are not unmindful of the great names of Inigo Jones and Wren, and there is reason to believe that at last our cities will be adorned by buildings which are other than hideous lies. Other names of present-day workers are Mr. Belcher of the Institute of Chartered Accountants, Mr. W. Young of the War Office, Mr. Reginald Blomfield, Sir Aston Webb in his latest work, Mr. Marshall Mackenzie, whose Waldorf Hotel might be more exciting, and many provincial architects in Glasgow, Edinburgh, and Dublin if nowhere else.

COURSE OF READING

Unlike painting, books on architecture are specially valuable and indeed necessary. They must always be accompanied by illustrations. The best known general history in English is that of Ferguson, but a more modern book is Banistin Fletcher's, the photographs and sketches in which are specially valuable. A good deal of minute detail which could not be dealt with in the short space given to this article can be followed out in these books. And it is worth doing thoroughly. It adds intensely to the appreciation of a great cathedral to understand in some way the principles of, let us say, roofing employed. To start with, however, the booklets on the subject in the *People's Books* and the *Home University Library* should be kept at hand. They are written from a very different standpoint.

Probably, however, if external stimulus is needed to interest the student nothing could be found better than Ruskin's masterpiece, *The Seven Lamps of Architecture*. If one is left cold by this there is no use going further. The same writer's *Lectures on Architecture*, delivered in Edinburgh, and the *Stones of Venice* and some of Walter Pater's essays will follow. It is not necessary to agree with all the social, far less the artistic, aims of Ruskin. His greatest detractors will be the first to recognise the enormous persuasive power of the writer. Stimulated by Ruskin, and it is hoped having obtained a fair acquaintance with the aims of the architects of different ages from these pages, the reader will be ready to attack the large histories. For the different periods and styles one may consult the works of Flinders Petrie and Lethady for Egyptian and Greek periods respectively, and of course, the British Museum's catalogues and pamphlets are invaluable in their completeness of up-to-date information.

The number of books on English and French Gothic and Renaissance churches is countless. Few, however, give more than excellent illustrations of some less known buildings. Otherwise the larger histories already mentioned are recommended, and give all the necessary information. It is a very interesting avocation to obtain guide-books of the local churches and mansions and test their accuracy by one's knowledge. The general principles of architecture, as Ruskin said, may be learnt as easily as those of a new card game, and in England and France it is not necessary to take long railway journeys to find beautiful examples in stone. Photographs, especially privately taken, are of surpassing value in this study. Unfortunately picture postcards are not often taken from an artistic point of view.

Lately various publishers have formed volumes of photographs of our chief cathedrals. West's *Gothic Architecture in England and France* is a very handy volume, and Blomfield's *Smaller History of Renaissance Architecture* may be used as a companion to it. Scotsmen are rightly proud of the engravings in Billing's *Baronial and Ecclesiastical Architecture of Scotland*. Heinemann's *Ars Una Series* under the headings of the different countries gives an excellent account, with small but good illustrations, of each nation's work.

J. Macpherson.

V. HISTORY OF MUSIC

THEORY AND APPRECIATION OF MUSIC

MUSIC as an independent art is entirely the product of western nations: when it has flourished elsewhere it is almost entirely in association with the dance or with poetry. Slow in its development, lagging centuries behind the sister arts, music is only now taking its proper place in the scheme of things, and its highly-organised language is at last being recognised as a full and complete medium for the expression of the inner life. The desire exists in everyone to express those thoughts and feelings which lie at the depths of our nature, to give utterance to those vague yearnings that are too deep for words. By art alone can this self-expression take form. And, when words fail, one or other of the arts may succeed. To many, music is but a beautiful thing, a pleasure, no doubt, but, as a means of expressing thought, hardly to be taken seriously. As music is developing, more and more is asked of it, and the wider seems the scope of its powers.

No biography will teach the true musician the inner nature of Beethoven so fully as does a study of his symphonies and sonatas. The unmusical man, reading the diary of Samuel Pepys, misses the very finest qualities of that interesting gossip if he does not fully comprehend how the diarist loved music before all things. As in the lives of men, so in the lives of nations. The popularity of Tschaikowsky's Pathetic Symphony reflects the pervading pessimism of the late nineteenth century quite as accurately as the writings of poets and novelists. The relation of music to life is much more intimate than is generally believed, and the fact that the nineteenth century saw the most rapid developments of music is provocative of thought when we remember the enormous concurrent developments in social, political, and industrial affairs. There is in it a fine study of cause and effect as interacting forces. The rapidity of development is characteristic of twentieth-century music as well. There can be no going back to the state of things when simplicity and paucity of material prevailed. Music can never be the same as if Wagner, Strauss, and Elgar had never lived. It has acquired and is acquiring new powers, and its activity to-day is one of the signs of the times. Time was when to be manly was to be strong physically, to be brutal, and to despise the influences of the arts: to-day, on all hands the refining influence of music is recognised, and its place in the life of nations is steadily increasing in importance.

HISTORY

The history of music begins with the history of mankind, and with the oldest of all instruments—the human voice. Research has done much, and year by year the mists which obscure the dawn of civilisation are being pierced; but, even so, the beginnings of music are a matter of surmise. Yet surmise may be truth, and probably we must go back to nature for the origin of the musical art. Musical sounds are not necessarily music, for they may lack graduated pitch and rhythm; and the cries of human beings and animals can hardly come under the category of music. But some cries, though lacking in clear definiteness, are often associated with certain expressions of feeling and become recognisable by repetition. The cuckoo call is the rudest of musical tunes. If two such cries be combined and make an impression by changes of pitch in time, an elemental form of music has arisen. After all, "singing is but beautiful speaking," and music may well have arisen in crude vocal efforts to express pleasure or pain.

Ancient Music.—Research has taught us much about the music of Eastern nations. Monumental remains in Egypt show us that the art was practised in the homes, while bands of singers and players provided vocal and instrumental music in the practice of religion. Hebrew music was probably taught orally, but no examples have come down to us: the biblical records are explicit and familiar. They show its importance during war and in the service of the Temple. Slabs and bas-reliefs indicate the martial nature

of Assyrian music, and massed bands of instrumentalists seem to have accompanied their forces into battle. The Romans had no distinctive music of their own, but acquired the art from the Greeks, and it is from the music of the Greeks that modern music is derived. Though little is known of its practice in Greece, the theory of music is largely commented on by Greek writers. It was a vital part of their religion, and was an essential component in the scheme of Greek education. Our chief interest lies in the scale which they employed.

Many people are so accustomed to our modern scales, that it comes as a surprise to find that they are not natural, but conventional. The notes and intervals of our major and minor scales were not chosen to be used in harmony, for harmony was unknown before the fifteenth century. Music did not come out of the scales; the scales were evolved as a result of long experimenting, both conscious and unconscious. If the reader plays a series of eight white notes on a piano, beginning with C, he will notice that no black notes lie between the third and fourth and between the seventh and eighth notes of that scale. Thus the series of four notes from C to F comprises two whole tones and one half-tone, and similarly the series from G to upper C comprises two whole tones and one half-tone. Each of these groups of four was called by the Greeks a tetrachord. By combining two such tetrachords, (1) C to F, and (2) G to upper C, we get our modern major scale, which, only so far as distribution of intervals is concerned, represents the Greek Lydian scale. If D be now made the starting-point, the first tetrachord, D to G, will have its half-tone between the two whole tones, and the second tetrachord, A to upper D, will have its half-tone in the same position. This was the Phrygian scale of the Greeks, so far as distribution of intervals is concerned. Similarly scales of eight notes can be built upon each of the other white notes of the scale, E, F, G, A, and B. The varying position of the half-tones gives each of these scales a distinctive character. All of these scales were employed in Greek music, and different qualities were found in them—one being considered manly, another inspiring, and another voluptuous.

Mediæval Music.—Music as an art had its origin in the Church. About the year 330, Pope Sylvester founded a singing school in Rome, and the singing, built upon the old Greek scales, must have been unisonal, and antiphonal. Later in the century Ambrose, Bishop of Milan, formulated what is known as the Ambrosian chant and provided the Church with four scales, taken from the Greek system. These were known as the Authentic Modes. Four others, known as the "Plagal Modes," were added in the sixth century by Pope Gregory the Great. The Ambrosian chant became in time the Gregorian chant, and this chant was the basis of ecclesiastical music in Europe throughout the Middle Ages.

Without some means of recording musical sounds, music could make no progress. Letters had been used by the Greeks and Romans. In the eighth century these gave place to "neumes," or a series of characters written like the letters, above the syllables with which they were associated. These neumes only indicated the rise and fall of the melody. By the tenth century a long red line was used, all neumes on this line representing the note F. One note fixed, the rest was easy. A yellow line drawn horizontally became the C line. Hucbald, a Flemish monk, added more lines, but Guido of Arezzo, a Benedictine of the eleventh century, is considered the real founder of our modern system. He is generally credited with the disposition of notes on the staff lines, and is called the father of solmisation since he employed the terms ut, re, mi, fa, sol, la (taken from the initial syllables of an old Latin hymn) for the notes of the scale.

When men began to sing in two parts, some distinction had to be made in the relative value or length of notes. Franco of Cologne, in the twelfth century, invented a system of measured time notes, by varying the shape of the symbol. Besides this he invented rests, and distinguished between dual and triple time. Our breve and semibreve come from his system.

For centuries music was purely melodic. The Greeks may have known something of harmony, but one of the first writers upon harmony was the monk Hucbald. He added a second part to the chant or *cantus firmus* then invariably sung by the tenor part. This added part consisted of a series of fourths or fifths below the melody, following it in parallel motion. Thus,

It will be found a very distasteful sequence to the modern ear.

Once men knew how to add a second part, ornamentation progressed, and thus grew up the art of descant. Franco of Cologne recommended motion in contrary directions, and as music was entirely written for voices, men preferred a style wherein each part was a melody in itself. The art of descant in time merged into the art of counterpoint, and this music of the Church was the music of the Middle Ages. Organs had been introduced, but they only played the voice parts as support.

Counterpoint is the art of "weaving two or more melodies together in such a way as to observe the rules of harmony." Composers began to imitate the descanters, whose crude extempore efforts gave way to more scientific processes. Instead of a free descant, the air itself was used in developing counterpoint.

Thus, the air, having been announced by the treble (say), was handed over to the tenor (say), who repeated it while the treble sang a different tune over the original theme. The highest development of this was found in fugues of Handel and Bach; but the Middle Ages were also the days of counterpoint.

Secular music was cultivated at the time by the Troubadours, Trouvères, Jongleurs, Minnesingers, and at a later date by the Meistersingers; and the names of Richard Cœur de Lion, in the company of the Troubadours, of King Thibaut of Navarre, and Adam de la Hale, among the Trouvères, hold high place. Those who know the Wagner operas will be acquainted with the Minnesinger Wolfram von Eschenbach and the Meistersinger Hans Sachs.

Not a great deal is known of English music in these early days, but one specimen of the music of the period is of outstanding merit. "Sumer is icumen in" is quite the finest piece of counterpoint or "polyphony" of those days. It is a "canon," wherein the air is carried by each of the voices in turn with perfect design, ingenuity, and pure beauty.

The Netherlanders.—The social and political condition of Europe was against artistic developments in the fourteenth century, but with the opening of the fifteenth there were signs of revived energy in the practice of the art. This is said to be due to the inspiration of John Dunstable, but the glory of the period is the great Netherlander school, which carried counterpoint to a high state of perfection. The first important composer of this school was William Dufay of Chimay. He is said to be the first to use secular airs as plain songs in the service of the Mass. One song used by him—"L'Omme armée"—was employed by almost every composer of contrapuntal music. John Okeghem was another noted composer of the century, but Josquin des Près, born about 1450, was the flower of the period. He aimed at pure beauty at times, and his elegance of style and command of technical devices led Luther to say, "Josquin is master of his notes: they must do as he wills: other composers must do as the notes will." During the fifteenth and sixteenth centuries, the Netherlands produced a large number of musicians who won high positions in Germany, France, and Italy. Amongst these was Adrian Willaert (1480–1562), chapel-master at St. Mark's, Venice, who frequently arranged that his voice parts should come together in successions of chords, and thus achieved broad mass effects. His successor at St. Mark's, Cyprian de Rore, made a study of chromatic harmony, and showed how beauty could be attained away from the Church modes. Arcadeldt was famous for his madrigals, and Orlando de Lasso (1520–1594) had a reputation second to none throughout Europe. His "Penitential Psalms" are characteristically beautiful.

The mathematical side of music made a strong appeal to these Netherlanders, and often originality and ingenuity took the place of beauty. They invented all sorts of curious music—"crab" canons, where the second voice sang the first voice part backwards, inverted canons, where the second part was the first theme written upside down, riddle canons, and other highly difficult and technical varieties in the manner of musical puzzles. The spirit of the music was often lost in the letter.

It fell to the Italians to depose the Netherlanders from their high estate before the close of the sixteenth century. The old plain song had dignity and was the basis of Church music. But the introduction of popular airs had a scandalous effect upon the service of the church. Tunes associated with frivolous words were introduced, and congregations sometimes sang these airs to the popular and ribald words with great gusto. The state of Church music attracted the attention of the Council of Trent in the middle of the sixteenth century, and a complete reform of Church music was resolved upon. It was at this juncture that Palestrina produced his three great Masses, of which the chief is known as the *Missa Papæ Marcellæ.* These Masses embody the finest and noblest expression of the polyphonic style, and in their lofty devotional spirit form the most serenely beautiful religious music ever written. Palestrina's control of technical resources conceal the underlying art, and the most exquisite effects for voices along with pure choral beauty are the outcome of his instinct for vocal composition. Pure melody, exalted feeling, and simple means are always present in his work, and the austerity and lack of passion are quite in keeping with the requirements of the Mass. But with Palestrina comes a turning-point in the history of music. Polyphonic music for voices never rose to a higher pitch, but the early writers of opera and oratorio were soon to turn the thoughts of musicians towards new lines of development.

English Music.—When Henry VII gave peace to England, the country had time to revive her interest in the arts. Under the Tudors,—themselves no mean musicians,—music became a vigorous pursuit. Before the Reformation there had been a very capable school of native musicians, and when the country turned from the old Church, and had to revise its liturgy, many of the older composers gave the Reformed Church the benefit of their services. The name of John Marbecke is familiar through his adaptation of the traditional plain song to the needs of the Reformed liturgy. Then Thomas Tallis and William Byrde wrote music for both the old and new rituals. These were also the days of famous organists, and the names of John Taverner, John Redford, John Sheppard, and Christopher Tye stand high in the esteem of musicians.

It was in Elizabeth's reign that music was held in highest esteem, and was an essential part of the education of a gentleman. This was the great madrigal period. The madrigal was a favourite form of composition with Netherlander and Italian composers, but some of the most beautiful were written by Englishmen. "In Going to my Lonely Bed" is ascribed to Edwards, and was written in the middle of the sixteenth century. It is a singularly charming composition. But the publication of the "Musica Transalpina" had greater force in directing native musicians towards this class of composition, while "The Triumphs of Oriana," a collection made in praise of Queen Elizabeth, contained contributions from Thomas Bateson, Michael Este, and that fine writer of Church music, Orlando Gibbons. Much fine music was also written by Thomas Weelkes, John Dowland (the lutenist and composer of "Songs or Ayres in Four Parts"), John Wilbye, and John Benet. Besides the writing of glees and madrigals, other forms of composition flourished. Richard Farrant excelled in Church music; John Bull composed characteristically for the organ, while the virginals—an early forerunner of the piano—were supplied with plentiful music of dance variety, such as pavanes and galliards. England held her own worthily in those days, and music was held in higher repute than it has ever been since.

The Transition Period.—The year 1600 has been taken as a convenient date from which to start the study of modern music, and the early seventeenth century saw many and complete changes in the development of the art. Polyphonic music, constructed entirely upon interwoven melodies, gave place to monodic music, wherein one principal melody was prominent and was supported by harmonies of a subordinate nature. The old Church modes were supplanted by the modern major and minor scales, and instrumental music began to be cultivated as a thing independent of association with the voice. Further, opera and oratorio had come into existence and played a strong part in all these developments.

Opera had its rise in a deliberate attempt of some Florentine classical scholars and amateur musicians to revive Greek drama. These dilettanti met in the house of Giovanni Bardi, Count of Vernio, and it was their intention to use music as a means to intensify the effect of poetry of the drama. Contrapuntal music did not suit their purpose, and believing that Greek drama was chanted, these amateurs invented a new style, which they hoped was like the declamatory style of the Greeks. A contemporary writer says, "The new music is a kind of melody so sung by a single voice that the words are well understood." This was what we now call "recitative," and its invention is due to Bardi's circle. Connected with this group were Galilei, father of the scientist, Cavaliere, Rinuccini the poet, Caccini, and Jacopo Peri, whose *Dafne*, written in 1597, is, though lost, considered to be the first opera. *Eurydice*, by the same composer, was first performed in 1600, and, except for some choral writing, was in the style of the new recitative. But the first real genius in the operatic style was Monteverde (1568–1643), whose operas, *Orfeo, Arianna, and Il Ballo della Ingrate*, show great developments. His melodies had greater freedom, and his harmony was much in advance of his time. He realised that music in association with words must add significance to the underlying emotion, and so he used sharp dissonances. Monteverde also employed a large body of instrumentalists, and was one of the first to use pizzicato (plucked) and tremolo effects. Cavalli (1599–1676) in his chief work, *Giasone*, foreshadowed the use of the aria, which to this day is the leading feature of popular Italian opera.

Oratorio takes its origin from St. Philip Neri, founder of the Oratorians, who encouraged the performance of biblical plays with music for the edification of the people. But it was Cavaliere, one of Bardi's circle, who wrote the first oratorio, *La Rappresentazione dell' Anima e del Corpo*, which was produced in 1600. The earliest oratorios were performed upon the stage, and dramatic qualities were then, as now, the chief feature of the musical form. The development of oratorio was similar to that of opera, and the aria is found dominating both art forms at this and later periods. Carissimi and Stradella worthily sustained the aims of Cavaliere. Allegri and Frescobaldi were also noted writers of Church music.

The *Eurydice* of Peri attracted great attention throughout Europe, and early specimens of opera are also found in France and Germany. The favourite form of musical dramatic entertainment in England was the masque, of which Milton's *Comus*, set to music by Henry Lawes, is a fine specimen.

The modern style of instrumental music also had its rise in Italy. Vocal music reached a high state of development long before independent instrumental music had made a true beginning. The viol, lute, and organ had been used entirely in association with the voice, but, with the improved state of instruments, music for instruments began to be written independent of the voice. By the time that the organ needed less physical effort for its execution, and the viol and violin superseded the lute—a most difficult instrument to keep in tune—instrumental composition began to flourish. Those forerunners of the pianoforte, the clavichord, virginal, and harpsichord, were still in an early state of development, but nevertheless there are *Queen Elizabeth's Virginal Book* and the *Parthenia* to be studied as specimens of instrumental composition. A chest of viols, of different

sizes to correspond with the various voices, held the same place in a sixteenth-century household as a piano does to-day. These viols at first played vocal music, and if any vocal part was awanting, the corresponding viol filled in the part. It was an easy step from this to the writing of music fit for either playing or singing. So instrumental music gradually acquired a status of its own.

The Later Seventeenth Century.—In Italy opera continued to develop under Cavalli and his successors, for in that country opera-houses sprang up in all the chief centres. The aria, built upon a symmetrical plan and having nothing to do with the dramatic development of the plot, became a very popular feature in opera. In thus departing from dramatic fidelity the prominence of the vocalist was increased, and it fell to Alessandro Scarlatti (1659–1725) to establish the Aria da Capo. This is an interpolated air with a strong first section, a contrasted middle verse, and a third part which is a repeat of the first. It was admirable for the vocalist, but foreign to a sincere operatic scheme. Scarlatti founded the Neapolitan School, and his works are noted for the excellence of the vocal qualities. He also began the practice of writing a three-movement prelude to his operas which in time developed into the modern orchestral overture and, later, into the modern symphony.

Doubtless the growing importance of the violin gave Scarlatti some inspiration towards increasing the importance of the orchestral part. During the seventeenth century the great violin-makers lived and flourished. The Amati, Guarneri, and Stradivari families were all of Cremona, and there soon arose a school of Italian violinists whose works are epoch-making. Corelli (before all others), Vivaldi, Tartini, and Locatelli wrote immense quantities of music for the instrument. Corelli's work has abiding qualities. Its simplicity, dignity, and freshness are charms that outweigh any feeling of old-fashioned structure and expression.

The characteristic feature of French opera is the ballet. When Cavalli's operas were brought to Paris this lack of a ballet was felt, and it was left to Jean Baptiste Lully (1633–1687) to supply the want. Lully was in control of the Paris opera-house, and in 1672 began a highly successful career with *L'Amour de Bacchus.* With a clear eye for spectacular effect, he gave the Parisians what they wanted. His treatment of the overture was a solid piece of work, and his influence upon music of a purely instrumental kind was considerable. Lully's most noted successor was Rameau. He wrote with much charm and variety, and his *Castor and Pollux* was for long a favourite in France. Besides this, he was notable as a writer of theory. His artistic ideals were more refined than those of Lully, and his works have dance tunes interspersed that give them special charm. The French also excelled at this period in writing attractive music for the harpsichord, and the grace and fancy of the compositions for this instrument have much merit. Couperin (1668–1733) wrote abundantly for the harpsichord, and his suites—called by him *ordres*—are collections of dances, vivacious in rhythm and dainty in their musical attractiveness. Rameau also excelled in writing for the same instrument.

This was also the period when organ-playing and composition were growing in importance, since that instrument had by that time arrived at a fairly complete condition. Italy had its Gabrielis and Meruto (all organists of St. Mark's, Venice), and Frescobaldi, organist at Rome; Germany its Reinken; and Denmark its Buxtehude—all of whom were noted performers and composers. The northern composers were also engaged in the art of dramatic choral writing in the form of the church cantata.

In England, one name stands out before all others—that of Henry Purcell. Charles II had brought from his wanderings a taste for French music, and Pelham Humphreys had introduced it into English circles, but no contemporary composer will bear comparison with Purcell, who was equally great in church and theatre music. He carried on the fine tradition of English church music, yet was in close touch with the most advanced methods of his day. He anticipated Bach in his methods of obtaining characteristic effects of harmony, and as organist of Westminster Abbey produced a large number of odes and church music of the highest quality. As a writer for the stage his little opera, *Dido and Æneas*, has richness of idea and rare excellence, while his solo-writing was always distinguished by close attention to the meaning of the words. The thirty-seven years of his life were years of great accomplishment, and it is not without significance that he has been called the greatest native composer before the time of Elgar.

Contemporary with Purcell were many English composers, whose names are familiar to those interested in church music. Aldrich, Dr. Blow, Matthew Lock, the writer of the famous *Macbeth* music, and Michael Wise have honoured places among musicians of the time.

The Age of Bach and Handel.—Germany came late into the field with composers of the first rank, but once the Teutonic supremacy was established, it never lost its eminent position. The German mind had not been carried away by the Italian enthusiasm for the monodic school, nor had it lost its interest in counterpoint. The chorale was a prominent feature in the worship of the Reformed Church. Religious sincerity, concentration, and intense seriousness gave firmness and fibre to its music, and these qualities are found to perfection in the works of Handel and Bach.

George Frederic Handel (1685–1759) began his career as an instrumentalist in the orchestra of of the Hamburg Opera House. While still a schoolboy, he wrote motets for the church of his native town, Halle in Saxony, and his first opera was produced before he was twenty years old. Residence in Italy gave him an insight into Italian methods and brought him a fluency in writing for voices which served him well in later years. Coming to London in 1710, he wrote about forty operas on the Italian plan to suit the tastes of the day. He made huge fortunes, and, like other operatic impresarios, lost them. The friend of princes, he was the patron of London charities, and in time became a naturalised citizen. Operas, oratorios, cantatas, church and occasional music, flowed from his facile pen, and his fine organ concertos are the product of his intimate knowledge of that instrument, of which he was one of the greatest executants in those days. But his greatest work is found in his oratorios. *The Messiah, Judas Maccabœus, Israel in Egypt, Samson, Jephthah,* and *Theodora,* are the flowers of his genius. In these works Protestantism had its fullest expression, and their austerity, severity, and massivity are in full keeping with the serious Teutonic mind of his day. The giant personality of the composer is shown in their lofty conception and execution, and the force of his genius left its stamp upon our musical life for a century and a half.

John Sebastian Bach, born in the same year as his great contemporary, is the most completely Teutonic of all composers. Unlike Handel, he was not a public man, but wrote as opportunity, occasion, or inspiration demanded. He came from a family of musicians, and in his early days heard all the great organists. A student of Italian music, he never succumbed to its influence. The chorale was popular from Luther's time, and, round the themes of these grand old hymns, composers loved to exercise their contrapuntal skill. From this sprang the fugue, whose musical form gives it special suitability for the organ. For richness of idea, fertility of invention, and sheer beauty of design, the organ works of Bach are unapproached. Even when writing for clavier, voice, or chorus, this style, so intellectual, sincere, and serious, was ever present. In writing for voices, he cared less for the delights of melody than Handel did, but the Christmas Oratorio, the St. Matthew and St. John Passions, and the mighty B minor Mass, are superb creations, always significant of the inner life of man. Nothing is bald or meaningless: everything is expressive, and these characteristics are found in every line of the enormous quantity of music which he has left. The *Forty-eight Preludes and Fugues for Well-Tempered Clavier* are specially important. Before Bach's day, a clavier had only a few of its keys in perfect tune. When an instrument was invented, tuned equally well for all the keys, he wrote the immortal *Forty-eight,* to show that a composer was no longer limited to a small number of keys. These were not mere exercises, but works of wonderful beauty in themselves. Besides this, he reformed keyboard fingering, and brought to perfection the Suite, in which sets of dances are arranged in a form most agreeable to the artistic sense. He died in 1750. The legacy of Bach is the greatest treasure in all the literature of music. Three of his sons were distinguished musicians: Emanuel being credited with the honour of developing the sonata on modern lines.

The early eighteenth century saw Domenico Scarlatti, a noted writer for the harpsichord, and Pergolesi, a short-lived but inspired writer. Both flourished in Italy. Italian *opéra-bouffe* also had a beginning then; William Boyce, Thomas Arne, and Nares, were composing characteristic church music in England: Rameau was carrying on Lully's work in French opera, and Hasse and Graun were producing notable works in Germany.

The Later Eighteenth Century.—The type of polyphonic music, in which Bach and Handel were supreme, was not sustained by later men, and the pendulum swung to the harmonic and melodic side. This tendency was enforced by the violin-playing and execution of the great Italian executant-composers Corelli and his successors. The genius of the violin is for pure melody where one outstanding tune is associated with secondary harmonies of simple design. In contrapuntal writing—*e.g.* such a chorus as "And the Glory" from *Messiah*—all four parts are equally important: a solo violin part cannot be on an equal footing with the accompaniment. The Italian composers found their best medium of expression in the sonata. This was at first a suite of dances, of an alternately quick and slow nature. Its improved form came from the Germans.

Instrumental music was making great strides and operatic overtures were being detached from their surroundings and enjoyed for their own sakes. The general plan of the orchestra was the same in the eighteenth century as it is to-day; its treatment by composers has only differed as instruments and their execution have improved. The sonata, symphony, and string quartet are all products of this period, and the general plan of each is the same. The first movement is usually based upon two themes which are developed upon a fixed plan, though much is left to the ingenuity of the composer: the second is a slow movement, the third a minuet or scherzo (quick movement), and the fourth a presto, often written in rondo form. This is built upon a psychological plan, with alternately fast and slow movements, varied to suit the needs of the listener in matters

of expression and emotion; and the giants of this period are Haydn and Mozart.

Joseph Haydn (1732–1809) is called the father of the symphony, because he established the sonata form and applied it to the symphony. His reputation as a youthful composer brought him the patronage of Prince Esterhazy, an Austrian amateur, to whose household he became attached, at first privately and later as chapel-master. Here he had rare opportunities for experiment with a private band, for which he wrote an immense number of symphonies. The early ones are based on simple ideas with elementary design, but his development was rapid, and the later symphonies show far richer ideas and wonderful sense of form. He separated the movements of the symphony and introduced the minuet. So also his string quartets are slender things in his early days, but they are vigorous, finished products of real genius in his later days. Besides over a hundred symphonies, eighty quartets, twenty-five concertos, twenty-four trios, forty-four sonatas, nineteen operas, fifteen masses, several cantatas, and hundreds of dances, he composed the oratorio *The Creation.* Haydn was sixty-five years old when he wrote it, yet its freshness, simplicity, and significant orchestral and choral writing give it charm to this day. All Haydn's music is delightfully fresh and graceful: a child-like naïvété is often found in it, combined with a graceful sweetness that makes his vocal and instrumental music irresistible.

Mozart (1756–1791), the most precocious and gifted of musical geniuses, was Haydn's pupil. He composed a concerto at six years of age, and went on a triumphal tour through Europe as a harpsichordist at eleven. His short life was one of great activity, and he is equally great as a writer of opera, symphony, quartet, sonata, and choral work. The great symphonies in G minor, E flat, and C major are amongst his profoundest creations. Grace and refinement mark all his chamber music, while his sense of musical form gives perfect balance and fitness to everything he wrote. His operas were on the Italian plan, with a plentiful supply of arias and concerted pieces. *Idomeneo, Nozze di Figaro, Don Giovanni,* and *Zauberflöte* are his best-known works. His last great work was the *Requiem,* to which a romantic story is attached. Never before his time had the independent treatment of instruments been so fully exploited, while his sense of orchestral colour was wonderful. Haydn owed much to Mozart in his later works.

The works of Haydn and Mozart make a turning-point in the history of instrumental music, and the whole range of the tone-art was immensely widened by their efforts.

Operatic music at this period was completely under the sway of the vocalist, and dramatic fidelity was sacrificed to the demands of the prima donna. Gluck (1714–1787) attempted its reformation on more rational lines, putting the drama on an equal footing with the music. In his *Orfeo and Eurydice,* dramatic propriety was no longer sacrificed to musical or vocal effect, but music was used to enforce dramatic sincerity. Arias were not despised, but were appropriately employed, and *Che faro senza Eurydice* is a gem for all time. His reforms were further developed in *Alceste* and *Iphigenie,* and his famous quarrel with Piccini ended in complete victory for the reformer. Before Gluck's day the orchestra had never been significantly employed in reinforcing the emotion of the drama. Grétry also wrote popular French opera at this period.

Music also flourished in Germany, where the theorist Pleyel, and Dussek, writer of pianoforte music, and Romberg, composer of *The Lay of the Bell,* were fine composers.

The Age of Beethoven.—Ludwig van Beethoven (1770–1827), who had known Mozart and had had lessons from Haydn, perfected what these masters had established. With little opportunity for hearing good music in his youth, his wonderful genius was of slow development. His life was one long struggle with misfortune. The responsibilities of his early years, his unhappy love affairs, and the terrible affliction of deafness gave his life a sombre and gloomy hue; yet his work is the true culmination of the period that precedes him, and at the same time foreshadows the developments that were to revolutionise music during the nineteenth century. His early works are all in the accepted form of the day, and he crowned the work of Haydn and Mozart with the perfect treatment of the sonata form in his piano and violin compositions, early symphonies, and quartets. But the full fruition of his genius came in later days. The Septet and Kreutzer and other sonatas were complete productions of their kind, but the immortal nine symphonies, the great string quartets, the later piano sonatas, the violin concerto, the one opera *Fidelio,* the noble *Coriolan* and other overtures, and the impressive piano concertos have a concentrated force, a reflective intensity, and a universality in expressing the joys and sorrows of humanity, that are unrivalled in musical art. To accomplish his aim, he never hesitated to expand his forms and modify his designs to suit the demands of his noble purpose. In writing for orchestra, he used the instruments with a fitness and freedom never before attempted, and, if he wrote to a programme, he never sought to portray what stimulated him, but sought rather to portray his feelings under the influence of the stimulus. Austere and intellectual, inspired by spiritual passion and profound thought, the works of Beethoven sweep over the complete range of emtional experience, and his name is surrounded with an epic glory.

Beethoven lived when the Romantic Revival was prevalent, and others beside him were influenced by the spirit of the times. Franz

Schubert (1797–1828), son of a humble schoolmaster, and starting his career with a poor musical education, showed his powers as a song-composer very early. He hold important appointments at times, but his life was rather erratic, and he knew trouble. During his short life, masses, symphonies, quartets, operas, and cantatas, were produced with marvellous rapidity, for he was one of the most facile composers who ever lived, and though his music is diffuse at times, it has the charm of fresh and abiding melody. But his highest achievement is found in the hundreds of songs which he wrote. Before Schubert's time poetry had been associated with melody, and melody only. In spite of varying moods, most of the verses were sung to the same air, in hymn-tune fashion; but moods vary with the verses, and, unless the music is appropriate to the mood, there can be no artistic whole. As harmony developed with the use of modulations, greater fitness between words and music was possible, and the first great results are found in Schubert. His gift of melody was luxuriant and apt to run away with him, but in his great songs, like *Lindenbaum*, *Erlking*, *Wanderer*, *Ständchen*, *Haidenröslein*, and many others, the melody moves in a way that a good reciter would employ. Again, the accompaniments are not a mere secondary harmonic groundwork to support the melody, but the descriptive piano part seconds the emotion of the words and deepens the significance of the poetic emotion. Schubert is the progenitor of the modern art song.

Germany was the centre of an active musical life at this time. Hummel, Steibelt, Ferdinand Ries, and Weber were noted composers, and of these Carl von Weber (1786–1826) is the chief. The Germans were seeking a type of opera suited to their sterner taste and musical intelligence. Weber, already noted as a pianist, had set to music national songs, which had been very popular during the Napoleonic campaigns. His appointment at Prague to organise a real German opera led to the production in 1821 of *Der Freischütz*, in which there were no traces of Italian traditions. Its supernatural story and use of folk-song appealed to the German mind. It anticipated Wagner in its attempt to emphasize dramatic unity, but, for the musician, the wonderfully expressive orchestral part, gorgeous in colour and dramatically expressed, is its greatest charm. This opera was followed by *Preciosa*, *Euryanthe*, and *Oberon*, whose overtures are as fresh to concert audiences to-day as on the day when they were written.

In those days Italy had her Boccherini, her Viotti, a noted writer for violins, Clementi, a prince amongst teachers, Salieri, and Cimarosa. In France, Cherubini, also a writer of fine church music, Boieldieu, and Mehul, were upholding the standard of French opera, and England found in Dr. Crotch and Thomas Attwood writers of dignified church music, while John Field is credited with the invention of the Nocturne.

From Beethoven to Brahms.—This period covers some seventy years, and is the greatest period of development in musical history. Only the Elizabethan era in English literature can rival this age in the production of so many artistic geniuses. It was a period not only of progress and development, but of revolution. Opera can never be the same since Wagner's mighty reforms: instrumental music is vastly more expressive since Berlioz's day, and its possibilities have been so far increased that to-day we cannot see their limits. Oratorio has revived in a new form since Elgar wrote *Gerontius*; Liszt and Chopin revolutionised piano virtuosity; and the song under Schumann, Hugo Wolf, Brahms, and others, has been cultivated in a manner worthy of its lyric importance. It was a period of great activity, when composers not only built upon the foundations of their predecessors, but found new avenues of expression and fresh fields for musical operation. The older classic forms were found too narrow and confined for the new aims, and fresh forms were invented. The established rules of harmony, tonality, and musical structure were rudely upset, and the full fruits of these revolutionary forces we are only just beginning to realise. Some aims were too high, and some experiments too wild, but greater permanent changes have been experienced by music in the last hundred years than in any previous age.

Italian opera was on the old lines. It was frequently a mere string of arias and concerted pieces, all written for the exemplification of favourite vocalists' powers, and dramatic unity was sacrificed to the needs of the prima donna. There was a plentiful supply of musical material for this purpose. Rossini (1792–1868) in his *Barber of Seville*, *Gazza Laddra*, *Tancredi*, *Semiramide*, and a host of others, gave the Italians the fluent melodies and vocal cadences which they loved; but his melody was never vulgar, and much of his music is scholarly. Donizetti in *La Favorita*, *Lucia di Lammermoor*, and *The Daughter of the Regiment*, did the same thing in an agreeable way, and Bellini had his day of popularity with *Norma* and *Sonnambula*.

The best-known musician in the early days of the century was Spohr (1784–1859). His operas, like *Jessonda*, had considerable vogue, and his oratorio *The Last Judgment* had something of the romanticism of later days. But, outside his symphonies, concertos, cantatas, and quartets, he is of prime importance for the attention he gave to compositions for the violin. He had an extraordinary instinct for the instrument, and his *Violin School* is invaluable. As a composer, his music has a chromatic quality in advance of his time, but his *sugary* harmonies give it undue sentimentality.

France was particularly successful in the production of light operas, which were distinguished by much nimble wit and dainty finish. Auber in *Fra Diavolo* and Hérold in *Zampa* were successful writers of the time. The chief figure in the Parisian operatic world was Meyerbeer, an extraordinarily clever musician. He knew French character, and, recognising the Gallic love of scenic display and spectacle, hit the popular taste in *Robert le diable*, *Le Prophète*, *Les Huguenots*, *Dinorah*, and others. His music suited the needs of pompous spectacles, and has been not unfitly described as a "huge pill of clever artificial emptiness." The great operatic geniuses of the age were Verdi and Wagner. Verdi (1813–1893) began his career by writing operas on the usual Italian plan of arias, chorus, and recitative, without much respect for the dramatic continuity of action. *Rigoletto*, *Il Trovatore*, *La Traviata*, *Ballo di Maschera*, and *Sicilian Vespers*, were all in the manner of Scarlatti and Rossini. Sensuous melody, shallow but catchy airs, made these operas popular in every opera-house of Europe. But in 1872, he brought out *Aida*, a work of much pathos and nobility of conception, and more dramatically sincere than anything he had written before. In his old age he wrote *Otello* and *Falstaff*, which showed further advances. In them there is the old Italian love of musical beauty, but the orchestration is richer and more expressive, and organic unity is achieved by throwing over the old forms used in his early works. Verdi had the advantage of a fine librettist in Boito, himself a composer of high merit, whose *Mephistophele*, though episodic, is nobly composed.

In Charles Gounod (1818–1893), France had an operatic composer of far finer calibre than Meyerbeer. *Faust* is touched with the true spirit of romanticism, and has melodic beauty of an alluring kind. It is more satisfactory on its lyric and picturesque than on its dramatic side, and its voluptuous airs are imbued with much of a mystic character. His other operas, *Philémon and Baucis*, *Reine de Saba*, and *Romeo and Juliet*, provide *prime donne* with favourite airs. Contemporary with Gounod and natives of France, were Bizet, whose *Carmen* is a fresh and sparkling work; Ambroise Thomas, composer of the charming *Mignon* and *Hamlet*; Delibes, writer of attractive ballet music; Massenet and Chabrier.

Wagner.—Germany was represented in opera by Nicolai, who wrote a bright version of *The Merry Wives of Windsor*, and Goldmark, whose *Queen of Sheba* has spectacular and musical merits. But the commanding figure in the world of opera is Richard Wagner (1813–1880). What Gluck and Weber attempted, Wagner established. Knowing the theatre from his youth, he was early acquainted with the works of Weber and Beethoven. At first he wrote in the manner of Meyerbeer, but the strong dramatic character of *Flying Dutchman* (1842), and its striking orchestration make this opera the first of a revolutionary series. Then followed *Tannhäuser*, *Lohengrin*, *Meistersinger*, *Tristan and Isolde*, the tetralogy known as *The Ring of the Nibelungs*, and *Parsifal*. Poetic text, music, and stagecraft were all of equal importance, and each opera shows advance in the accomplishment of this ideal. His scores were orchestral symphonies, seconding the stage action and flowing uninterruptedly throughout the course of the play. His harmonic progressions were most daring for his time, his chord relationship most advanced, and his use of the brass and wind sections of the orchestra was novel in the unusual importance given to these instruments. By the free use of *Leitmotiv* he associated each character with a definite musical figure, and the richness of his score and scope of his conception have left an indelible mark upon the development of modern music. Wagner's life was a stormy one, but his strong personality kept him from deviating from his high purpose, and though at times he attempted what was hardly dramatically possible, the *Ring* is the greatest achievement in operatic composition.

The most popular composer during the middle part of the nineteenth century was *Felix Mendelssohn-Bartholdy* (1809–47). All the good fairies were present at his birth, and the gifted youth had the advantage of an education in a wealthy and artistic household. His precocity was soon seen, for the beautiful *Midsummer Night's Dream* overture was written before he was twenty years old. In every department of musical composition except opera (*Lorelei* was unfinished) he left worthy contributions to musical literature. The *Hebrides* overture is choicely picturesque, the *Songs without Words* are admirable material for budding pianists, the Violin Concerto is a vital thing, the Scotch, Reformation, and Italian Symphonies are rich in expression, the chamber music and songs are agreeably melodious, and the choral works, *Hymn of Praise*, *St. Paul*, and *Elijah*, are eminently dramatic for their day. Mendelssohn was a writer on classical models, and his propaganda in the matter of Bach is unforgettable. But his facile pen led him to write much that was obvious and trite, though in his finest moments he is on a level with the greatest. We are only to-day breaking away from the thraldom of the oratorio form as fixed by *St. Paul* and *Elijah*.

In choral work, Gounod had written *The Redemption*, a disjointed work with some good choruses, and César Franck, a composer little appreciated till after his death, showed in his *Beatitudes* wonderful qualities of sincerity and feeling. Schumann's *Paradise and the Peri* and Berlioz's impressive *Damnation of Faust* had high merits. The Bohemian composer Dvorak, towards the end of the century, used his skill

in picturesque writing and highly-coloured orchestration with dramatic effect in his *Spectre's Bride*, and wrote a beautiful *Stabat Mater*. But the highest standard was reached by Brahms in the heavenly *Song of Destiny*, the *Triumphlied* and the *German Requiem*. In England the church organists turned out hosts of choral works on the Mendelssohn pattern, of which Sterndale Bennett's *Woman of Samaria* and Sullivan's *The Golden Legend* are good types.

The cult of the song developed as the century grew. Gluck's theories made people think of the intimate connection between words and music. Mozart, Haydn, and Beethoven had approached the ideal, but Schubert was the first to express himself fully in this art-form. Melody was no longer the one factor in the musical scheme; the harmonic background of the accompaniment was equally effective in deepening the significance of the music, and the great song-writers fused these into an organic whole. Mendelssohn's songs were agreeable enough, but not in the best line of art. Schumann, born a year after Mendelssohn, was a composer whose music had all the associated qualities which great poetry demands. He was the real musical exponent of Heine. Deep feeling and warm colour stamp all his songs. *The Two Grenadiers*, *Ich grolle nicht*, *Du bist wie eine Blume*, and all the Dichterliebe series are perfect examples of the song-art. Carl Loewe's *Edward*, Liszt's *Kennst du das Land?* Hugo Wolf's *Verborgenheit*, Brahms's *Sapphic Ode* and *Feldeinsamkeit*, Dvorak's *Biblical Songs*, Grieg's *Swan* and *Ich liebe dich*, are a few specimens of the best songs of the century. The latter years of the century saw this cult of the art-song carried forward by almost all composers of note.

Even greater developments were made in instrumental music. *Frederic Chopin* (1809–1849) was the poet of the piano, and his music breathes the artistic proclivities of his native Poland. His preludes, nocturnes, waltzes, mazurkas, sonatas, scherzos, ballades, and studies, are the creations of an original genius. They are full of delicate charm and freshness of idea; tenderness, refinement, and perfect finish take the place of strength and vigour. Classic forms were unsuited to express his inspirations, and he wrote with great freedom and with a novelty of rhythm and harmony that has high romantic qualities. His piano works are a never-ending source of joy to players and audiences.

Robert Schumann (1810–1856) was also a true romantic, and could not express himself within the limits of classic bounds. A ripe scholar and thinker as well as a pianist spoilt in the making, he took to composition as an afterthought. His short piano pieces, *Papillons*, *Carnaval*, *Kinderscenen*, *Novelletten*, and the fantasia *Faschingsschwank aus Wien*, are all highly imaginative works. Rhythm did not appeal to him as to Chopin; poetic sensibility was more to him than form. He sought out new modes suited to the art of expression, and many of his pieces have definite names which are clues to his poetic intention. The same sensitiveness and freedom from formal restraint mark his symphonies and chamber music. The *Pianoforte Quintet* is one of his finest works.

Liszt.—As the dexterity of executants increased and instruments improved, composers made further experimental voyages. One feature of nineteenth-century music was the extension of what is called "programme" music. This was really no new thing: the mere giving of a name to a work implies the general idea of a programme. The new mission of music owed much to the art theories of Franz Liszt (1811–1886), a prince in the realm of music. He regarded all the arts—poetry, painting, and music—as one and interdependent. Thus music was one other medium to express what might be conveyed through painting or literature. The ideas which music was to convey were not necessarily musical ideas, but might be a story, or even an incident in life.

Rameau and Couperin had written little picture tunes: operatic overtures had outlined the story of the opera; and Spohr's symphonies, *The Power of Sound* and the *Seasons*, indicate a pretty plain programme. In his Twelve Symphonic Poems, Liszt sought to exemplify his theories. In *Les Préludes* he took some elusive lines of Lamartine in comment on certain phases of life, and gave a musical transcription of their varying moods. Other symphonic poems are named *Tasso*, *Orpheus*, *Mazeppa*, &c., from which names their character may be judged. This meant a breaking away from the sonata and other classic forms. As a pianist and composer for the piano, Liszt ranks with the greatest exponents of that instrument.

Hector Berlioz (1803–1869), greatest of all French composers, broke away entirely from these forms, and his eager, impulsive nature, extraordinarily sensitive to the tone qualities of various instruments, led him to make numerous experiments. His chief contribution to the music of the century was found in the new combinations of instruments which he exploited, and his great gifts for rhythm and orchestral colour had been a tremendous influence on the treatment of the orchestra during later days. The older forms were useless for his purpose, which was to depict human experiences and narrate stories in musical terms. What he attempted may be seen from the names of his works—*King Lear* Overture, a symphonic fantasia called *Episode de la Vie d'un Artiste* (a sordid tale), and *Harold in Italy*. Berlioz and Wagner were the two greatest forces in the development of orchestral composition during the century.

Brahms.—Johannes Brahms (1833–1897), the greatest figure in the second half of the century,

was in the direct line of the classic composers. He was great in every branch of music except opera, which he did not touch, and his music has the stamp of lofty sincerity and dignified severity in all its aspects. The austerity of his music hindered his early recognition, and his want of sympathy with the development of music drama kept him out of favour for a long time. Though his great symphonies were in the classic form, Brahms was always original and individual within the classic limits. As an intellectual composer, he placed greater emphasis upon musical ideas than upon mere orchestral colouring, and the seduction of "programme" writing did not appeal to him. Piano quartets and quintets, chamber music of all varieties, symphonies, concertos, pianoforte music of many kinds—all had the loftiest treatment with rare skill in design. Some of his songs are amongst the greatest ever written.

During the whole of the nineteenth century, England never failed to recognise and encourage musical talent of native or foreign extraction. The popularity of Sir Arthur Sullivan was unrivalled during the latter part of the century, and his light music, associated with the Savoy operas, at once clever, scholarly, and captivating, made its appeal to musical scholar and average man alike. Sir Hubert Parry, one of the most learned of musicians, has written much in the spirit of Bach and Brahms, and the severity and technical excellence of his music are always impressive. Sir Charles Stanford and Sir Alexander Mackenzie have been successful in the opera form, and their scholarly works are worthy products of men who rank among the best teachers of the day. Sir Frederick Cowen, a conductor of high merit, has written operas and oratorios, and his songs have had considerable vogue. Parry, Stanford, Mackenzie, and Cowen are still alive and musically active; England lost a graceful composer of much originality when Goring Thomas died at an early age. The modern school of English musicians owed much to the enterprise and fine qualities of these men, who paved the way for Elgar and his contemporaries, for they worked in the face of much discouragement. English audiences love oratorio, and, until the close of the nineteenth century, would accept nothing but the Handel-Mendelssohn tradition. Brave efforts were made to break away from the stock pattern, but without avail. The popular composer was Sullivan, who found his true *métier* in light opera, but, without depreciating his charming work in the slightest, it must be recalled that he was never entirely successful in his more serious compositions. A wealth of fine music will be found in the works of Mackenzie, Cowen, Stanford, Goring Thomas, and the scholarly Parry, and lovers of good music may well explore the music of these men. They have been eclipsed by Sir Edward Elgar, but their sincerity of purpose and lofty aims have nobly upheld the good name of English music.

Music since the Death of Brahms.—Johannes Brahms died in 1897, and with him departed the last of the great classic composers. It has been said that the best music of to-day is as far removed from Wagner as Wagner was from Mozart. This only means that composers to-day have different aims. With Mozart, music was a thing of beauty; with Wagner, a means of enforcing the significance of verse and dramatic action; with the modern, it is more psychological, and seeks to express the deepest feelings of our innermost being.

There is a great change in the attitude towards musical form. The modern view is that the subject should dictate the form, not the form the matter. This is partly the result of the popularity of programme music. When Richard Strauss wants to depict musically the last hours of a dying man, he cannot do so by taking a theme or two, Beethoven-wise, and by elaborating them according to the rules of the symphony. Instead of a few themes, he uses many, and uses them as they express the varying moods of his musical narrative.

Besides a breaking away from form, there is a revolution in method. There is a new attitude towards tonality. Schumann discovered that by keeping down the loud pedal of a piano, music could be written in which two tonalities (*i.e.* two different keys) could be heard simultaneously. So the modern musician changes his key with almost bewildering frequency—often several times in a bar. Harmony is no longer regarded as a matter of rule, but of reason and feeling. The musician uses his chords like a painter does his colours, and it has been said that "Each chord has its own colour, and each arrangement of the chord its special tint." Chords are now used according to the effect they produce.

Some composers have gone back to the modes of the mediæval church; others, like Debussy, have adopted the whole-tone scale (*i.e.* a scale with eight whole-tone intervals throughout). Even quarter-tones have been experimented with.

There has been a rapid advance in instrumental and vocal execution. The Sevcik School of violin-playing and the Lechitizky school of piano playing have greatly heightened the general level of execution upon these instruments. Since Wagner and Berlioz wrote their treatises, there has arisen a school of orchestral conductors who treat the orchestra as one vast instrument, and give to the rendering of great orchestral works the stamp of their own individualities. Among the most prominent interpretative conductors are Arthur Nikisch, Sir Henry Wood, Weingartner, and Landon Ronald. Hans Richter, the doyen, has now retired.

Each country in Europe (America has no

prominent composer) has its representative musicians. The popularity of the Russian school, especially in England, is one of the features of recent years. Tschaikowsky, Glazounow, Rachmaninoff, and Arensky, are familiar names on our programmes. The former won favour first by his Pathetic Symphony, and his wealth of pleasing melody in this, in his songs, and in his simple piano pieces, as well as in his greater works, has made him popular with the average concert-goer. The barbaric splendour of his orchestral canvas has its sensuous and exciting qualities.

Norway had its Edward Grieg, a composer of no small charm. He had unmistakable mannerisms of melody and harmony, and a certain freakishness was not awanting. His songs are picturesque; his tone poems for piano, neat and subtle; his *Peer Gynt* suite has fine moments and his violin sonatas are elegant compositions.

Germany is represented by the schools of Richard Strauss and Max Reger. Strauss is a musical realist. His "programme" works, like *Don Quixote*, *Heldenleben*, *Death and Transfiguration* and *Till Eulenspiegel*, demand a huge orchestra and are the most advanced specimens of their type. In his scores he imitates such objective realities as the bleating of sheep and the death rattle, while a phrase in one of them represents the character of a lady. His operas, like *Elektra*, are no less realistic, and some of his songs rank amongst the finest written since the death of Schubert. Max Reger follows Bach and Brahms, but with a strong modern feeling intruding itself.

Modern French music began with the saintly César Franck. Camille Saint-Saens, still alive and busy, belongs to an earlier day. Debussy is the best-known representative of this school. As a musical impressionist, he evolved a system of tonality, and aims at what a painter would call "atmosphere." His aim is to suggest rather than to state definitely: so that much of his work is dreamy, elusive, and evanescent. His songs are of the same character, and in his experimental music drama, *Pelleas and Melisande*, the music in the orchestra is made inferior in importance to the spoken word. Vincent d'Indy and Maurice Ravel also belong to this school.

Italy, since the death of Verdi, has been fairly prominent in opera, and the blood-thirsty, crude melodramas of Mascagni, Leoncavallo, and Puccini, are associated with music which has popular if not great characteristics.

In Sir Edward Elgar, England has the first really great composer since Henry Purcell. As a composer of choral music he is a pioneer, and *The Dream of Gerontius* marks an epoch in the history of oratorio. This work is a complete departure from the Handel-Mendelssohn tradition, and is treated fully in the modern spirit. His other works, *King Olaf*, *Caractacus*, and *The Apostles*, are all stamped with his peculiar idiom. Elgar writes good, clear melody, composes for a large orchestra, and, though hardly a revolutionary, is modern in his use of key relationships and harmony. His scholarly symphonies, noble variations (Enigma), and brilliant violin concerto, are amongst the most notable contributions to the music of the day. As a composer, he ranks with Strauss and Debussy.

English music is a flourishing plant to-day, and there is quite a host of capable composers, very active in our midst. Delius, who has French tendencies, Granville Bantock, Josef Holbrooke, Rutland Boughton, and Vaughan Williams, are only a few of many native musicians who are worthily maintaining the reputation of England in musical composition.

STAFF NOTATION

Preliminary.—Sound is caused by air in motion, and a musical tone is created by the vibrations of the air being regular and continuous. If the vibrations are irregular or broken, a mere noise is produced.

Musical tones may be (*a*) high or low, (*b*) long or short, (*c*) loud or soft, (*d*) pleasant or unpleasant, and the terms for these elements are (*a*) Pitch, (*b*) Duration, (*c*) Intensity, (*d*) Quality or Timbre.

Pitch.—Let middle C be struck on the piano and the seven white notes above and below be played. In each case a note will be arrived at which the ear recognises as having a very decided relation to the middle C. The octave note, or eighth note above, is thinner and clearer; the octave note, or eighth note below, is fuller and richer than the original note. This is caused by a different number of vibrations being set up in each case; and the similarity of all notes which are octaves to each other comes from a definite relationship between the vibration periods. A very simple instrument called the siren can be employed to ascertain the number of vibrations set up by any note. In the case of middle C, it is found that they are about 256 per second. The octave above has double the number of vibrations of the original note—here 512—and the octave below half the number—here 128. So that the difference between three such notes is, *ceteris paribus*, only a matter of pitch.

Now, if the keyboard be examined throughout, it will be found to group itself into sets of eight white notes, from C to C, each set, when played, being bounded by notes which are octaves. If any of these groups be played through, a feeling of completeness and finality is experienced. Such a group of eight notes is called a scale.

This grouping is more plainly seen when we examine the position of the black keys. In association with each of the above groups of eight white notes, there will be found five black

ones always in the same position as below in Fig. 1.

FIG. 1.

Each note of the scale has a name as above. If C be struck on the piano, then the black note between C and D, and then D itself, the ear will perceive that the sound of the black note lies between the sounds of C and D. This will appear more plainly if it be imitated vocally. The same may be done for any pair of white notes with a black one between. But it will be noticed that there is no black note at two points in the scale—*i.e.* between E and F and between B and C¹. If an attempt be made to sing a note between E and F or B and C, as can be done between any two other adjacent white notes of the scale, it will be found to be impracticable. It can be deduced from this that the distance between E and F and between B and C is approximately the same as between a white note and an adjacent black one. This difference of pitch is called a semitone, or the interval between a white note and the adjacent black note above or below, or the interval between two white notes when no black note intervenes. When a sequence of two white notes is struck, having a black note between, the interval is a whole tone. Thus C to D is a whole tone. If we play an ascending scale, we usually call the black notes Sharps (indicated ♯), in descending scales they are called Flats (indicated ♭). On the piano C♯ is the same note as D♭, D♯ is E♭, &c. Actually there is a difference between C sharp and D flat, for their number of vibrations per second is not the same. This distinction is made in violin and in vocal music: but the piano is so tuned that for practical purposes they are identical. This series of eight white notes beginning on C is called the scale of C, or the natural scale.

A musical notation must make provision for every possible note, natural, sharp, or flat. If a hymn tune, written in staff notation, be examined, it will be found that there are two groups of five horizontal lines bracketed together as in Fig. 2.

FIG. 2.

If the hymn tune is sung, the upper group applies to women's or boys' voices and the lower group to men's; if the tune is played, the right hand plays from the upper group and the left hand from the lower. Each group is known as a Staff or Stave: the sign  is called the Treble Clef, and  the Bass Clef. The perpendicular line joining these staves is called a Brace.

The gap between the staves was introduced for the purposes of separation; in old music the gap was filled up by a horizontal line, which completed one staff of eleven lines, and music was written upon what was known as the Great Stave. In modern notation, this line between the staves is used in a detached form as in Fig. 3.

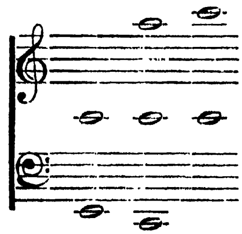


FIG. 3.

Any notes occurring above the treble or below

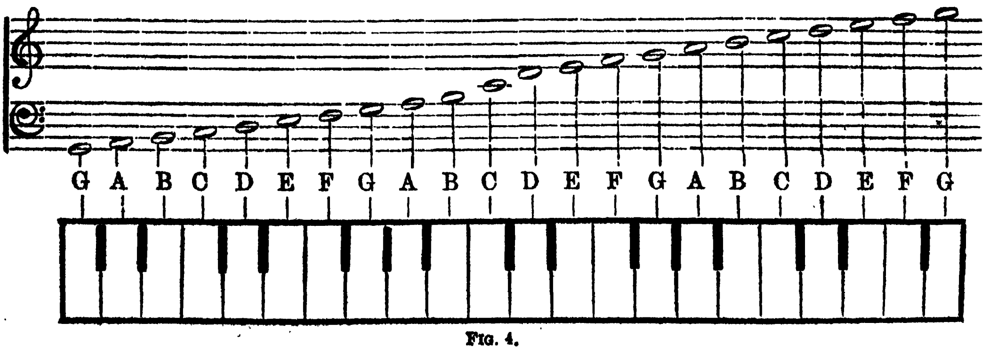


FIG. 4.

the bass clef are indicated in a similar way as in Fig. 3. Such broken or detached lines above, between, or below the stave are called Leger-lines.

The broken line between the staves in Fig. 3 represents the middle C of a piano; the space between C and the lowest line of the treble clef represents D, and the space between C and the uppermost line of the bass clef represents B on the piano. Similarly, the lowest line of the treble clef represents E, and the uppermost line of the bass clef represents A. These spaces and lines are called the degrees of the scale, and they correspond to the keys of the piano, as in Fig. 4.

The names of the notes and their position should be memorised thus:

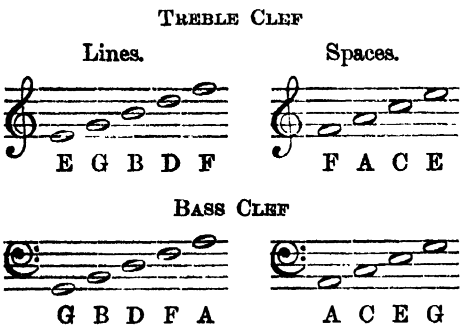


Fig. 5.

Special attention should be given to the three notes between the staves and to the first few notes above and below the stave, thus:

Fig. 6.

Scales and Keys.—The scale of C, or natural scale, consists entirely of white notes on the piano, and is written in staff notation as in Fig. 7.

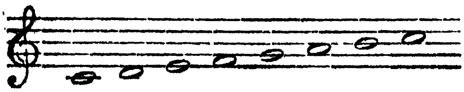


Fig. 7.

It is called the scale of C because its degrees are governed by the starting note C, which is called the Tonic. By comparing this with the notes on the piano, it will be found that the tones and semitones distribute themselves as in Fig. 8.

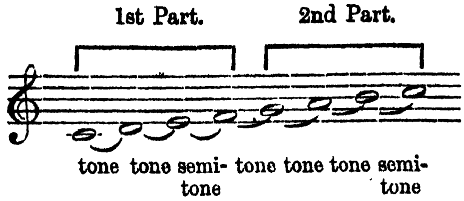


Fig. 8.

This divides itself into two similar parts. The first, from C to F, consists of two tones and a semitone, and the second, from G to C, comprises the same intervals.

Sharp Keys.—Let us take the second part of the above scale—*i.e.* G to C—and make it the first part of a new scale. Play eight consecutive white notes, using G as the tonic. The ear will find the second last note (F) unsatisfactory. On examination, it will be found that the second half of our new scale does not correspond in the distribution of intervals with the first. The final two intervals are successively a semitone and a tone when they should be a tone followed by a semitone. To make it correct, we must play F♯ (*i.e.* the black note above F) on the piano and our new scale becomes

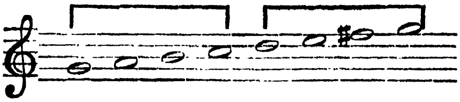


Fig. 9.

With the change, the new scale will please the ear. Let us take the second half of our new scale and, using D as our tonic, play a succession of eight notes, thus—D, E, F♯, G, A, B, C, D. Again the second last note is unsatisfactory, and must be sharpened as in the previous case. Our new scale is seen in Fig. 10, written an octave down for convenience.

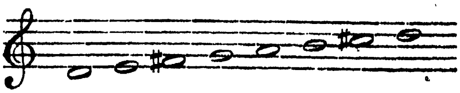
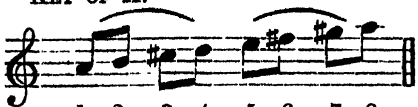


Fig. 10

Now G is five notes, or at an interval of a fifth, above C. D is a fifth above G, and so, when we carry this on, we will get a new scale with A as tonic if the second last note of this third scale be sharpened. The second last note—called the Leading note—is the determining factor in all these scales. From this we arrive at all the Sharp Keys, as they are called. For our purpose

only other five keys are necessary, and these are written in full as follows :

KEY OF A.

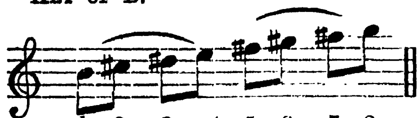


1 2 3 4 5 6 7 8

KEY OF E.

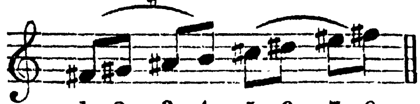
1 2 3 4 5 6 7 8

KEY OF B.



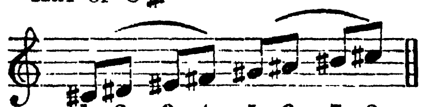
1 2 3 4 5 6 7 8

KEY OF F♯.



1 2 3 4 5 6 7 8

KEY OF C♯.



1 2 3 4 5 6 7 8

FIG. 11.

Flat Keys.—If we write the natural scale downwards, thus :

1st Part. 2nd Part.

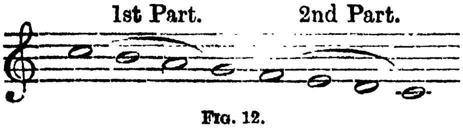


FIG. 12.

we may use the lower or second part as the basis of a new scale, *i.e.* with F as the tonic of a new descending scale. Lifting this group of four notes up an octave for convenience and playing eight white notes down, thus :

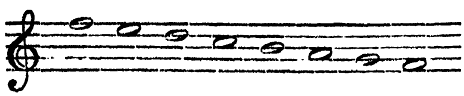


FIG. 13.

we find that there is something unsatisfactory to the ear at the fifth note down (B). On comparing it with the C scale, we find that the intervals do not correspond in distribution. In the natural scale, there is a whole tone between the fourth and fifth notes of the descending scale : here there is only a semitone. This can be rectified by flattening B, and the scale as below quite satisfies the ear. Thus it becomes

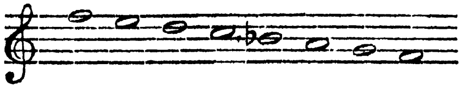


FIG. 14.

and the black note, now played, gives the scale its proper character. This is the scale of F.

If a descending scale be now played with B♭ for our tonic, the first four notes will sound all right, but the fifth in descent will sound unsatisfactory for the same reason as was found in the scale of F. By flattening this fifth note (E) the downward scale sounds satisfactory, and is written

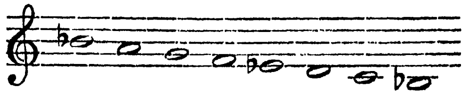
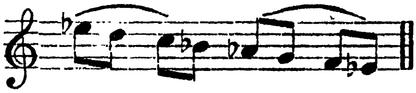


FIG. 15.

This is called the scale of B♭.

The test note in all these scales is the fifth down, and, from the above, a new set of scales may be compiled. Thus we get the following scales.

KEY OF E♭.



KEY OF A♭.

KEY OF D♭.

KEY OF G♭.

KEY OF C♭.

FIG. 16.

It will be seen that the mass of sharps and flats is very great in some scales, and their appearance upon a sheet of music would be very confusing. To avoid this, the sharps and flats necessary to any scale, are written once for all

at the beginning of the staff just after the clef sign. They are not repeated when the notes occur in the music unless for a very special reason. This device also serves to indicate the key in which a piece of music is written. Thus the scale of D is written and is called the key of two sharps—

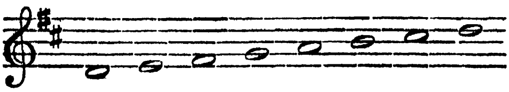


FIG. 17.

instead of—

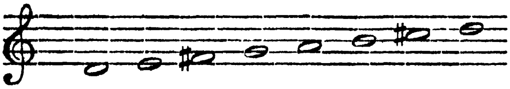


FIG. 18.

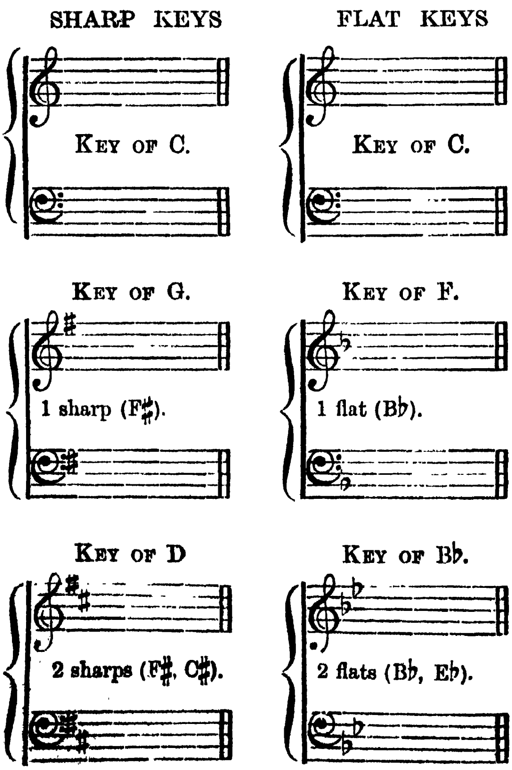
Three other signs should be noted here :

× used to raise a note two semitones, and called a Double Sharp.

♭♭ used to lower a note two semitones, and called a Double Flat.

♮ restores a note on any line or space to its original or normal pitch, and is called a Natural.

The following is a table of the common Major Sharp and Flat Keys.



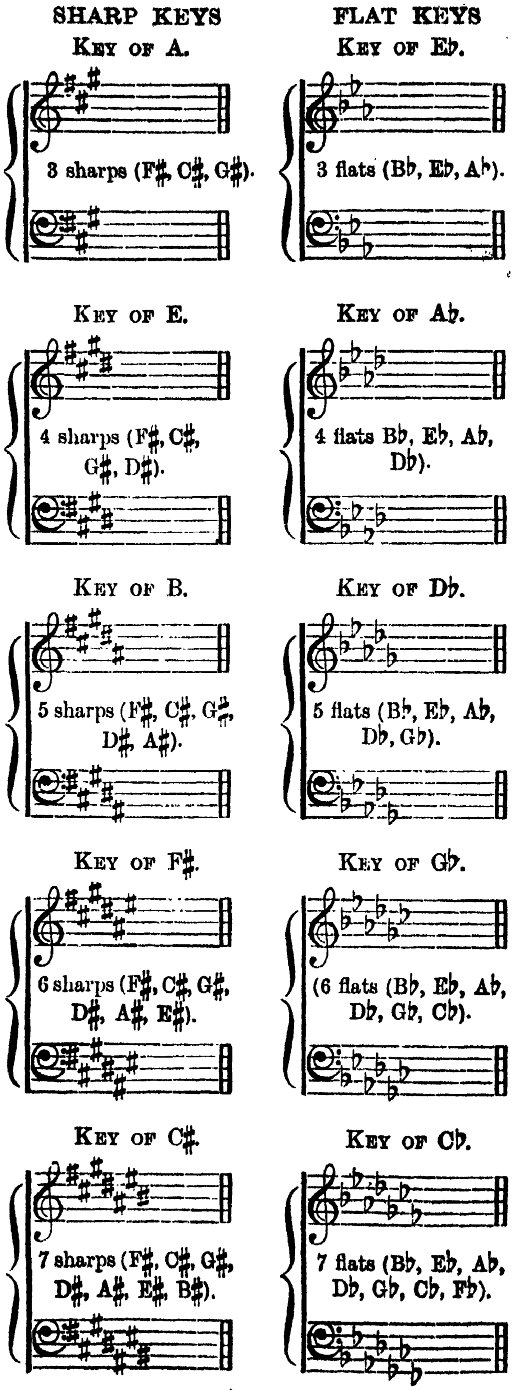


FIG. 19.

The scales set forth above are called diatonic because they consist mainly of whole tones. There are two kinds of diatonic scales—Major

and Minor. Those above are the major scales, and are so called because the interval from the first to the third notes consists of two whole tones.

If a scale of eight notes be played on white notes of a piano beginning with A instead of C, it will be noticed that semitones occur between the second and third notes and between the fifth and sixth. The interval from the first to the third notes consists of a tone and a half. Thus:

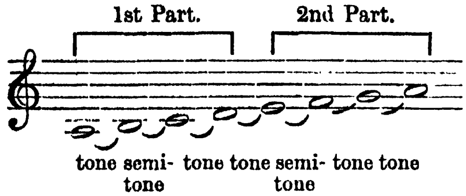


FIG. 20.

A scale such as this beginning on A, the third below C, is called a Minor Scale. If we take the third note below the tonic of any major scale as our starting-point and play the notes of that scale, we get a scale of eight notes which is called the Relative Minor to our major scale. Thus the relative minor of G begins on E, of D on B, of A on F♯, of F on D, or B♭ on G, &c. But there are three forms of the minor scales as written below:

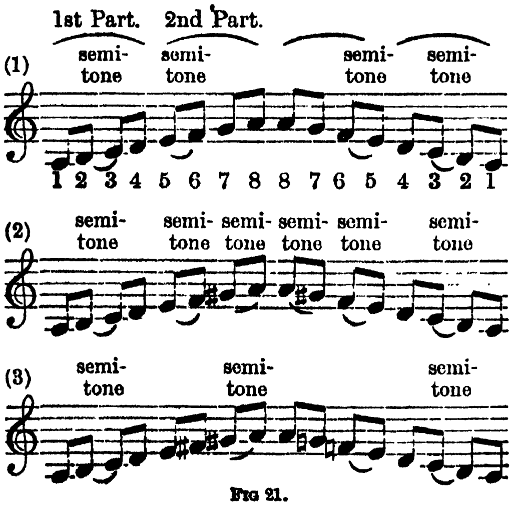


FIG 21.

No. 1 is not commonly used to-day.

No. 2. has the advantage of being the same both in its ascending and descending forms (the Harmonic).

No. 3 is the one commonly used (the Melodic).

Besides the Diatonic Scales there is the Chromatic Scale, obtained by playing or singing all the notes, black and white, in succession from any note to its octave above or below.

Duration of Sounds and Accents.—Hitherto we have dealt entirely with pitch. The pitch of any note is known from its position on the staff; the duration of the sound it represents is known by its shape. In modern music six kinds of notes are most commonly employed with 𝅝, known as a semibreve, for the unit. All other notes are taken as fractions of this.

𝅝 a whole note, called the Semibreve.

𝅗𝅥 or 𝅗𝅥 a half „ „ „ Minim.

𝅘𝅥 or 𝅘𝅥 a quarter „ „ „ Crotchet.

𝅘𝅥𝅮 or 𝅘𝅥𝅮 an eighth „ „ „ Quaver.

𝅘𝅥𝅯 or 𝅘𝅥𝅯 a sixteenth „ „ „ Semiquaver.

𝅘𝅥𝅰 or 𝅘𝅥𝅰 a thirty-second note, called the Demi-semiquaver.

A note ||𝅜|| called the Breve, is found in older music.

Thus a Semibreve 𝅝 = 2 Minims 𝅗𝅥 + 𝅗𝅥

= 4 Crotchets

𝅘𝅥 + 𝅘𝅥 + 𝅘𝅥 + 𝅘𝅥

= 8 Quavers

𝅘𝅥𝅮 + 𝅘𝅥𝅮 + 𝅘𝅥𝅮 + 𝅘𝅥𝅮 + 𝅘𝅥𝅮 + 𝅘𝅥𝅮 + 𝅘𝅥𝅮 + 𝅘𝅥𝅮

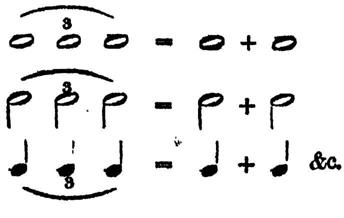
= 16 Semiquavers

𝅘𝅥𝅯 + 𝅘𝅥𝅯 + 𝅘𝅥𝅯 + 𝅘𝅥𝅯 + 𝅘𝅥𝅯 + 𝅘𝅥𝅯 + 𝅘𝅥𝅯 + 𝅘𝅥𝅯 +
𝅘𝅥𝅯 + 𝅘𝅥𝅯 + 𝅘𝅥𝅯 + 𝅘𝅥𝅯 + 𝅘𝅥𝅯 + 𝅘𝅥𝅯 + 𝅘𝅥𝅯 + 𝅘𝅥𝅯

&c.

To save writing so many crooks, it is customary to write quavers and subdivisions of quavers thus:

Sometimes it is desirable to play or sing three notes in the same time that is usually occupied by two of similar value, and to indicate this a band is placed over the three with the figure 3 above: thus



But melodies often give moments of silence, break off and begin again, and there must be some way of indicating this. So we have what are called rest signs, thus:

A rest = 𝅝 is 𝄻 like a weight hanging from a line.

𝅗𝅥 „ 𝄼 like a weight resting on a line.

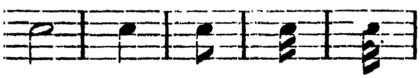
♩ „ 𝄽

♪ „ 𝄾

𝅘𝅥𝅯 „ 𝄿

𝅘𝅥𝅰 „ 𝅀

This similarity of quaver and crotchet rests needs noting.



and

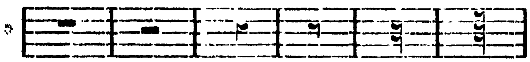
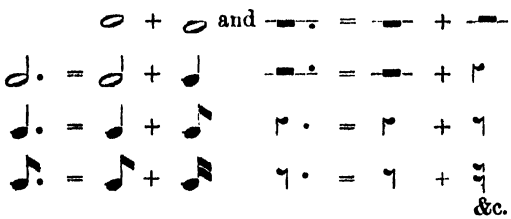


FIG. 22.

Half, quarter, and eighth values in rests and notes are indicated by dots.



We have now shown how notes can be represented for pitch and for length. It now remains to see how they work out in combination. Everyone knows that the essence of poetry is metre with its recurring accents of strong and weak. So in music there are accents of strong and weak. and the simple device of a bar-line is employed. It is drawn just before the note on which a strong accent comes.

The following notes represent the first line of the Hundredth Psalm without bars.

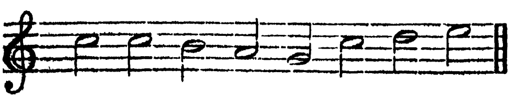


FIG. 23.

The words of the Psalm are accented thus:

"All people that on earth do dwell."

So the above music is barred:

FIG. 24.

Here there are two notes or beats between each pair of bar-lines. The portion of music between any two bar-lines is called a Bar, and in the above each bar is equivalent in duration to two minims. It happens that the above has all its notes of equal value, and as two minims equal one semibreve, any arrangement of notes, the sum of whose time values equals one semibreve, may be admitted between two such bar-lines. Thus in the following, Fig. 25 shows this without rests.

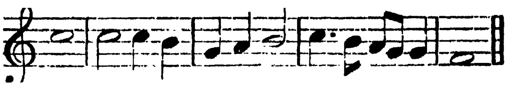


FIG. 25.

In Fig. 25 the first bar contains one semibreve; the second bar one minim + two crotchets = one semibreve; the third bar two crotchets + one minim = one semibreve; the fourth bar one dotted crotchet + one quaver + two quavers + one crotchet = eight quavers = one semibreve. Further varieties may be added with ingenuity.

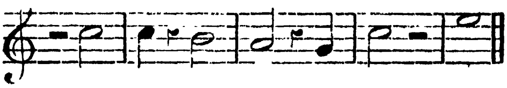


FIG. 26.

It is well that an indication should be given at the beginning of each piece of music to show where the accented note will come, and what is the total time-value of each bar. These indications are called Time Signatures, and consist of two numerical figures placed one above the other just after the clefs. Thus in the foregoing example, they would be written:

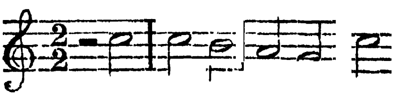


FIG. 27.

The lower figure 2 indicates the kind of notes employed in fractional parts of a semibreve, *i.e.* 2 = a minim; the upper number indicates the number of such notes to each bar. So $\frac{2}{2}$ means two minims is the sum of the time values of all the notes of each bar of the passage.

Similarly in Fig. 28—

FIG. 28.

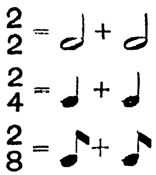
the figure 4 means the fourth part of a semibreve, *i.e.* crotchet, and 2 means that two crotchets is the sum of the time values of all the notes in any bar.

In Fig. 29 the time signature means two-

FIG. 29.

eighths of a semibreve in each bar, *i.e.* two quavers or the sum-equivalent of two quavers in duration.

When there are only two beats to a bar, the time is called Duple Time. The time signatures of Simple Duple Time are—



The following notes—with one minor change—represent the music of the National Anthem without bars.

FIG. 30.

The words of the National Anthem are accented thus:

"Gòd save our gràcious King,"

i.e. one accented syllable and two unaccented ones in each group.

The piece would be barred thus:

FIG. 31.

Here there are three minims to the bar, and as a minim is half a semibreve, and there are three of them, on the principle explained above, the piece would be marked $\frac{3}{2}$.

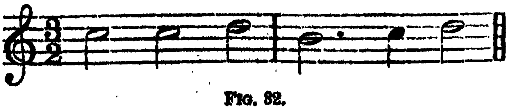


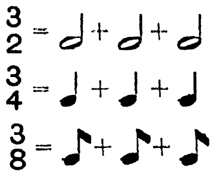
FIG. 32.

Written in crotchets or quavers, this phrase would be:

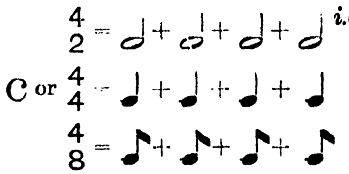
FIG. 33.

FIG. 34.

With the signatures $\frac{3}{4}$ and $\frac{3}{8}$ as shown, since a crotchet is a fourth and a quaver an eighth of a semibreve, when there are three beats to the bar, the time is called Triple Time. The signatures of the Simple Triple Times are:



When two duple times are combined we get Quadruple Time, with four beats in a bar instead of two. In ordinary duple time, the first beat is strong; in quadruple time, the first note is on the strong beat, the second weak, the third medium, and the fourth weak. The time signatures for Simple Quadruple Times are:



i.e. 4 minims in a bar.

4 crotchets in a bar.

4 quavers in a bar.

C or $\frac{4}{4}$ is also called Common Time and is written thus:

FIG. 35.

These are the simple times; but there are also Compound Times. A phrase like the following:

FIG. 36.

has six notes in each bar, grouped in pairs as shown by the curve, and hence has one strong

beat and two weak ones. But if the same six notes be grouped in threes, thus:

FIG. 37.

we have a strong accent on the first note as before and a medium accent on the fourth. This completely alters the character of the tune, which now combines simple and duple times. What we have here is two groups of three quavers and the time signature is as above $\frac{6}{8}$.

A complete scheme of Compound Times is—

COMPOUND.

Signature.	Value of each Bar.	No. of Beats.	Value of each Beat.
$\frac{6}{4}$	𝅗𝅥. 𝅗𝅥.	2	𝅗𝅥.
$\frac{6}{8}$	♩. ♩.	2	♩.
$\frac{6}{16}$	♪. ♪.	2	♪.
$\frac{9}{4}$	𝅗𝅥. 𝅗𝅥. 𝅗𝅥.	3	𝅗𝅥.
$\frac{9}{8}$	♩. ♩. ♩.	3	♩.
$\frac{9}{16}$	♪. ♪. ♪.	3	♪.
$\frac{12}{4}$	𝅗𝅥. 𝅗𝅥. 𝅗𝅥. 𝅗𝅥.	4	𝅗𝅥.
$\frac{12}{8}$	♩. ♩. ♩. ♩.	4	♩.
$\frac{12}{16}$	♪. ♪. ♪. ♪.	4	♪.

Throughout the above, the bars have been filled with notes, but the signatures hold good for the omission of notes when their rest-equivalents are shown, as

FIG. 38.

Signs and Abbreviations—*Definitions, &c.*— 𝄐 a pause mark over or under a note, indicates that the note must be prolonged or held on at the discretion of the performer.

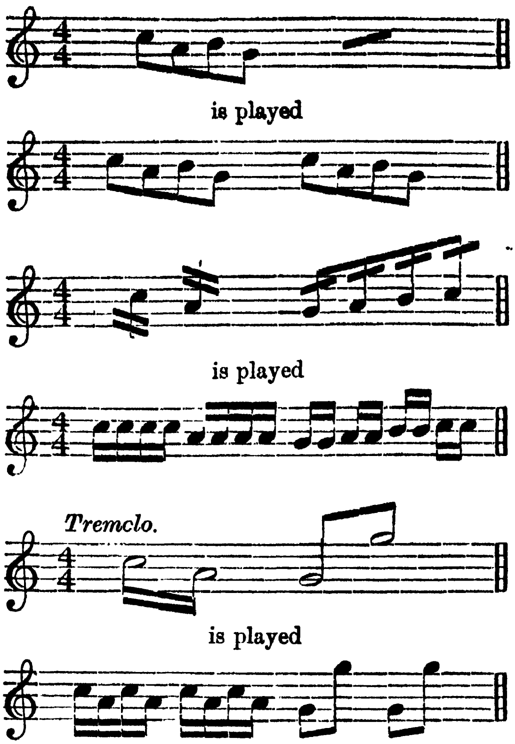
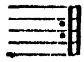


FIG. 39.

Repeats are shown variously. Thus,  means that the performer is to go back in the score to where there is the mark . Other marks are 𝄋 and D.S. (to go back to the sign), and D.C. (to go back to the beginning).

When the regular recurrence of accent is interrupted by any device, we get syncopation. Thus:

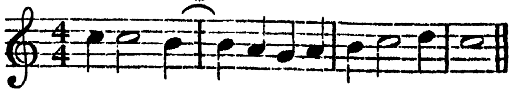


FIG. 40.

The Tie or Bind ⌒ means that the first note of the second bar is not played, but held from the previous bar.

Some of the principal musical terms are:

Adagio—slow and expressive.
Molto Adagio and *Adagissimo*—very slow.
Allegro—merry, lively.
Allegretto—rather merry, not so fast as *Allegro*.
Andante—at a moderate rate.
Andantino—gently, not so fast as *Andante*.

Accelerando—quickening the pace.
Allargando—decreasing the pace.
Ad libitum—at pleasure.
Agitato—with agitation.
Animato—animated.
A poco a poco—little by little.
Brillante—in a brilliant manner.
Ben—as in *ben marcato*—well marked.
Calando—decreasing.
Con brio—with energy ; *Con fuoco*—with fire.
Con expressione—with expression : *con moto*—with spirit.
Crescendo—increasing in loudness.
Decrescendo } *Diminuendo* } decreasing in loudness.
Dolce—sweetly, softly.
Forte—marked *f*—loud.
Fortissimo—*ff*—very loud.
fff—as loud as possible.
Grave—solemn, heavy, slow.
Grazioso—gracefully.
Largo—very slow ; *Lento*—slow.
Larghetto—not so slow as *Largo*.
Legato—smoothly, in a gliding manner.
Maestoso—in a grand, majestic manner.
Marcato—marked emphatic.
Mezzo-forte—*mf*—moderately loud.
Mezzo-piano—*mp*—moderately soft.
Moderato—at a moderate pace.
Mene allegro—less fast.
Non—not.
Piano—*p*—soft ; *Pianissimo*—*pp*—very soft.
ppp—as soft as possible.
Presto—quickly.
Prestissimo—as quickly as possible.
Piu mosso—quicker.
Perdendosi—losing itself.
Quasi—almost.
Ritardando—retarding.
Ritenuto—holding back.
Rallentando—slackening the pace.
Tempo commodo—at a convenient speed.
Tenuto—sustained.
Sforzato—forced ; *Sotto voce*—in an undertone.
Stringendo—hurrying the pace.
Vivace—lively, sprightly.

TONIC SOL-FA NOTATION

MOST modern music is based upon what we call the Common Scale, *i.e.* a set of eight notes, each having a definite relation to the first of the series, which we call the tonic or key-tone. If middle C of a piano be struck, and the seven white notes above or below it be played or sung, we get the Common Major Scale. In the Tonic Sol-Fa Notation, each note of the common scale gets a name, the tonic or key-tone of any major scale being called Doh, and written **d**—the other notes sung upwards are called Ray, Me, Fah, Soh, Lah, Te, Doh^1, and written **r**, **m**, **f**, **s**, **l**, **t**, **d**^{1}. As the eighth note is the octave of the first, it is marked **d**^{1} to distinguish it from the key-tone, always written **d**.

A chart of the Common Major Scale, called the Modulator, shows these notes thus :

Doh^1	**d**^{1}
Te	**t**
Lah	**l**
Soh	**s**
Fah	**f**
Me	**m**
Ray	**r**
Doh	**d**

It will be noticed on the above modulator that Doh^1 and Te are printed close together and also Fah and Me. This is because no semitones intervene in those two cases. On a piano there are no black keys between E and F and B and C, which in the key of C correspond to Me and Fah and Te and Doh in the Sol-fa system. Semitones can be sung between any of the remaining intervals.

To indicate notes above or below the common scale as shown above, numbers are used. Thus **d**^{1} is the octave note above **d**, and **d**^{2} is two octaves above **d** ; while **d**$_1$ is the octave below **d**, and **d**$_2$ two octaves below **d**. Thus the complete octave above the common scale is written—

d^1 **r**^{1} **m**^{1} **f**^{1} **s**^{1} **l**^{1} **t**^{1} **d**^{2}

and the complete octave below the common scale is

d **t**$_1$ **l**$_1$ **s**$_1$ **f**$_1$ **m**$_1$ **r**$_1$ **d**$_2$

Me^1	**m**^{1}	E
Ray^1	**r**^{1}	D
Doh^1	**d**^{1}	C
Te	**t**	B
Lah	**l**	A
Soh	**s**	G
Fah	**f**	F
Me	**m**	E
Ray	**r**	D
Doh	**d**	C
Te$_1$	**t**$_1$	B
Lah$_1$	**l**$_1$	A
Soh$_1$	**s**$_1$	G

From the accompanying diagram the correspondence of the notes of the Sol-fa system with the scale of C on the piano can be easily noted.

But as the black keys of a piano are the sharps and flats (or accidentals, as they are called) in the scale of C, so Sol-fah notation

makes provision for naming the semitones between notes, when such semitones occur. A sharp is indicated by writing the letter *e* after **d r f s l**.

Thus de is the sharp of	doh		(pronounced	dee)
re	„	ray	„	ree
fe	„	fah	„	fee
se	„	soh	„	see
le	„	lah	„	lee

A flat is indicated by the letter *a* after **r m s l t**.

Thus ra is the flat of	ray		(pronounced	raw)
ma	„	me	„	maw
sa	„	soh	„	saw
la	„	lah	„	law
ta	„	te	„	taw

A complete scale showing chromatic semitones is as follows:

	$d^{|}$	
	t	
ta		le
	l	
la		se
	s	
sa		fe
	f	
	m	
ma		re
	r	
ra		re
	d	

If the chromatic scale of C be played upwards on a piano, the sharp names de, re, &c., are used; if the scale be played downwards, the flat names ta, la, &c., are used.

Although in the above we have referred to the scale of C, which means that middle C is our tonic or key-note, it will be found possible to take any black or white key on the piano as key-note and play a scale up or down, using the above names for the notes of the chromatic scale. So in writing music in the Sol-fa notation some method must be employed to denote the pitch of the key-note. A little knowledge of the plan of the piano keyboard is required, for the key is always marked at the beginning of a piece of music in Sol-fah notation. Thus:

Key F.

d r m f s l t $d^{|}$

means that this scale is to be sung with F as Doh. A simple sequence of notes to be sung with D as tonic or key-note would be written thus:

Key D.

d r m s l $d^{|}$ s m d.

So far we have dealt with the Major Scale, but much music, especially of a graver and melancholy kind, is written in the Minor Scale. The modern Minor is represented in Tonic Sol-fa notation by the eight successive notes, sung from Lah$_{|}$ to Lah, thus:

$l_{|}$ $t_{|}$ d r m f s l.

Lah here is the key-note or Tonic as Doh is the Tonic of the Major Scale.

The difference of these scales will be found in the different positions of the semitones. In the Major Scale, the semitone intervals are **m** to **f** and **t** to **$d^{|}$**, *i.e* between the third and fourth and seventh and eighth notes of the scale; in the Minor Scale the semitone intervals are **$t_{|}$** to **d** and **m** to **f**, *i.e.* between the second and third and fifth and sixth notes of the scale. The relation of the scales is seen thus:

	Doh$^{|}$		Major Scale
		semitone	
	Te		
		tone	
Minor Scale	Lah		
		tone	
	Soh		
		tone	
	Fah		
		semitone	
	Me		
		tone	
	Ray		
		tone	
	Doh		
		semitone	
	Te$_{|}$		
		tone	
	Lah$_{|}$		

The Minor Scale is found in no fewer than three different forms.

In the first form we find it ascending and descending thus:

$l_{|}$ $t_{|}$ d r m f s l
l s f m r d $t_{|}$ $l_{|}$

But harmony demands what is known as the leading note, *i.e.* a semitone interval between the seventh and eighth notes of the scale. To obtain this we must sharpen Soh into Se, and the second form becomes

$l_{|}$ $t_{|}$ d r m f se l
l, se f m r d $t_{|}$ $l_{|}$

But here the interval from Fah to Se is difficult to sing, and so Fah is also sharpened a semitone, the new note being called, not Fe, but Bah (pronounced Bay). This is only applicable to the ascending form of the scale.

The third form, ascending and descending, becomes

$l_{|}$ $t_{|}$ d r m ba se l
l s f m r d $t_{|}$ $l_{|}$

It will be noted that the descending form differs from the ascending form. The term Ba is reserved for the Minor Scale.

Time.—Time in music may mean (1) the length of the note, (2) the pace of the music, (3) the regular recurrence of accent.

The speed of a tune is always indicated by what is known as the Metronome Mark, which is placed at the beginning of a piece of music, as M. = 66 means 66 beats per minute; M. = 80 means 80 beats per minute.

In music there are three kinds of accent—weak, medium, and strong, and these are marked by playing or singing with greater or less force. For example, in the word "abuse," the stress is

on the second syllable; in "ready" it is upon the first. In "lamentation" we have each kind of accent—*la* (medium), *men* (weak), *ta* (strong) *tion* (weak). In Tonic Sol-fa notation an accented note comes after a bar line. In such a line of poetry as

"Tell me not in mournful numbers,"

we have four stressed syllables and four unstressed syllables, and the line can be divided into feet thus:

| Tell me | not in | mournful | numbers |

The feet of poetry correspond to the measures or bars of music, and the accent of the above runs:

| strong weak | strong weak | strong weak | strong weak

Tonic Sol-fah notation employs these bar-lines, and as each space between two bars has here two syllables, a colon is put to divide them. Thus:

| : | : | : | : ||

The double bar shows the close of the musical phrase, and it is understood that the strong beat is upon the first note of the bar. If the above line of poetry were monotoned upon one note, the music would be written:

{| d :d | d :d | d :d | d :d
Tell me not in mourn-ful num-bers.

Here we have the accent of the first foot corresponding with the first beat of the bar. In the case of:

The way | was long, | the wind | was cold. ||

the poetic metres are as marked above. The line opens with an unstressed syllable, and, as the accent comes after the bar in Tonic Sol-fa notation, it would be grouped thus:

The | way was | long the | wind was | cold

If monotoned, the music would be written:

{| :d | d :d | d :d | d :d | d : ||
The way was long, the wind was cold.

Note that the blank spaces at the beginning of the first bar and at the end of the last one denote rests or silences, which must be mentally counted. As the distance between two bar-lines is called a measure, each accent marks a pulse or beat.

When, as above, there are two beats in a measure, and only strong and weak accents are used, the music is said to be in Two-Pulse Measure. If a piece of music, as in the first example above, begins on a strong accent, it is called the Primary form of two-pulse measure; if, as in the second case, on a weak accent, it is called the Secondary form. Thus the notation for the 100th Psalm would be:

KEY A. M. = 60.

{| :d | d :t_1 | l_1 :s_1 | d :r | m :m |
m :m	r :d	f :m	r :d
r :m	r :d	l_1 :t_1	d :s
m :d	r :f	m :r	d :	

If a piece of music contains three pulses, it is called Three-Pulse Measure. In the line:

I had a | day in the | country with | Miriam ||

we have four feet, each foot of three syllables, with the accent on the first; the other two being unaccented. If it were monotoned, it would be written:

{| d :d :d | d :d :d | d :d :d | d :d :d
I had a day in the coun-try with Mir-i-am.

As the verse accent comes here on the first note of the measure, it is called Primary Form.

In

Sing heigho, | the holly, ||

the accent is on the second syllable, and the notation of this phrase monotoned would be:

{:d | d :d :d | d :d ||
Sing heigh-o, the hol - ly.

Or in the lyric:

The Assy | rian came down | like a wolf | on the fold ||

the accent comes on the third syllable, and the notation of the phrase monotoned would be:

{| :d :d | d :d :d | d :d :d | d :d :d | d ||
The Ass-yr-ian came down like a wolf on the fold.

These later are both Secondary forms.

Many hymns are written with four beats to the bar. Here the accents are strong, weak, medium, weak, and the medium accent is shown by a shorter line than that which precedes the strong accent, thus:

strong weak medium weak
| : | : ||

This is called Four-Pulse Measure, and a typical tune in this measure is :

s |d' :t |l :s |s :f |m :m |

|r :d |f :m |r &c.

Two-pulse, three-pulse, and four-pulse measures are said to be Simple Measures ; by combining them, we get the Compound Measures. A measure made up of two three-pulse measures is called a Six-Pulse Measure. It is made up with the fourth accent a medium instead of a strong one. Thus :

{| strong : weak : weak | medium : weak : weak |

{| d' :t :l |s :f :m |r :m :d |t_1 :l_1 :s_1 ||

If three three-pulse measures are combined, a Nine-Pulse Measure is produced. Its Primary form is:

str. w. w. m. w. w. m. w. w. str. w. w. m. w. w. m. w. w.

{| d :r :m |r :m : f |m :f s |l :t :d' |t :l :s |f :m :d ||

In beating time to compound measures, only the strong and medium accents are indicated if the music is taken fairly fast.

Duration of Notes.—The pulse is the unit of duration, and can be divided up into parts or multiplied. In this musical phrase :

{|d :m |m :s |l :s |s :m

the time is two-pulse measure, and each note has one beat. If the length of each of these notes was doubled and given two beats, the phrase would be written

{|d :— |m :— |m :— |s :— }

{|l :— |s :— |s :— |m :— ||

If a note is sustained for more than one pulse, it is said to be continued, and this is shown by means of the horizontal lines. The pitch name of the note is only written once, and the horizontal lines show its continuance. For example :

{|d :—:— |m :—:d |s :—:l |s :—:— ||

or

{|d :— |— :d |s :— |f :— }

{|m :f |— :m |s

Similarly pulses may be divided. This is done by means of a dot, which divides a pulse into halves, thus :

{|d .d :d || or {|d :-.d:d ||

or

{|d :d.d|d.d:d |d :— |-.d :d ||

The quarter-pulses are marked by commas, thus :

{|

{|d,d.d :d . d,d|d,d.d,d:d . ||

If the pulse is divided into three equal parts, the commas are inverted, thus :

{| ‘ ‘ : ‘ ‘ ||

{|m‘f‘s : l‘t‘d' ||

A pulse divided into six equal parts shows whether the groups are three 2's or two 3's, thus :

{|d $\overset{3}{d}$ d.d $\overset{3}{d}$ d :d $\overset{3}{d}$ d.d $\overset{3}{d}$ d ||

{|d d‘d d‘d d :d d‘d d‘d d ||

Eighths of a pulse are shown :

{|d d ,d d .d d ,d d :d d ,d d .d d ,d d ||

Rests or silent pulses are shown by blanks :

{|d :— | :d |d : | .d:d |d :— ||

silent silent silent

Here the rests are for one beat in the first two cases, and for half a beat in the third.

Table of Pulses and Rests.

(1) Whole Pulse :

{|d :d ||

Whole Pulse Silence :

{| : ||

(2) Half-Pulse and Rest :

{|d .d :d . |d :— ||

(3) Quarter-Pulse and Rest :

{|d ,d .d ,d :d, .d,d ||

(4) Thirds :

{|d‘d‘d :d‘ ‘d ||

(5) Sixths :

{|d $\overset{3}{d}$ d .d $\overset{3}{d}$ d : .d $\overset{3}{d}$ d : .d $\overset{3}{d}$ d ||

or

{|d d‘d d‘d d :d d‘d d‘d d ||

Transition or Change of Key.—Examination of the common scale will show that it is made up of two parts, which, as regards the distribution of tones and semitones, are similarly built. The notes of the sequence **d r m f** are separated by intervals of one whole tone, one whole tone, and one semitone respectively; the notes **s l t** $\mathbf{d^{1}}$ are separated by exactly the same intervals as in the previous sequence. So if we make Soh a new Doh, and start a scale with that note as Tonic, our first sequence of four notes is in correspondence with the demands of the common scale. If we carry our new scale upwards to complete the octave, the Fah of the old scale becomes Fe, to provide the necessary semitone between the leading note and the upper Tonic, *i.e.* between Te and Doh in the new scale. Similarly in the descending scale, the notes of the sequence $\mathbf{d^{1}}$ **t l s** are separated by intervals of one semitone, one whole tone, and one whole tone; and the notes of the sequence **f m r d**, by exactly the same intervals. Here the Fah may be made our new Doh, and we may start a downward scale with that note as Tonic, our first sequence of four notes corresponding in intervals with the demands of the common scale. In carrying down a full octave, however, the Te of the old scale becomes Ta, to provide the whole tone necessary between Soh and Fah of the new scale. This may be best seen in what is called the Extended Modulator, where several scales are printed side by side, thus:

	Soh^{1}	d^{1}
	Fe	t^{1}
d^{1}	Fah^{1}	
t	Me^{1}	l
l	Ray^{1}	s
s	Doh	f
	Te	m
f	Ta	
m	Lah	r
r	Soh	d
	Fe	t$_{1}$
d	Fah	
t$_{1}$	Me	l$_{1}$
l$_{1}$	Ray	s$_{1}$
s$_{1}$	Doh	f$_{1}$
	Te$_{1}$	m$_{1}$
f$_{1}$	Ta	
m$_{1}$	Lah$_{1}$	r$_{1}$
r$_{1}$	Soh$_{1}$	d$_{1}$
d$_{1}$	Fah$_{1}$	

The change made when the **d** of the right-hand scale corresponds to the Soh of the middle one, is called the First Sharp Remove, and is the same as modulating from key of C to key of G. The distinguishing note of sucha change is the Te. Similarly the change made when **d** of the left-hand scale corresponds with Fah of the middle one is called the First Flat Remove, and is the same as modulating from key of C to key of F. The distinguishing note here is the Fah. It will be noted that in the case of the First Sharp Remove, the key-note is moved upwards an interval of one fifth (*i.e.* Doh to Soh), and in the case of the First Flat Remove it is moved upwards an interval of one fourth (*i.e.* Doh to Fah). By taking these new scales and applying the same artifices, other scales may be formed. Thus, the Soh of our new right-hand scale may become the Doh of another new scale, but this Soh is the Ray of the original scale. So the Tonic of the Second Sharp Remove is got by taking the Ray of the original scale and building upon it. Similarly it will be found that the Tonic of the Second Flat Remove will be the Ta of the original scale. A complete set of Sharp and Flat Removes may then be worked out. When a change of key occurs in a piece of music, it is indicated in two ways—(1) the name of the new key is printed over the note where the change occurs, and (2) a "bridge tone," printed in small type, shows the relation of the first note in the new key to the original key. As for example:

```
  KEY C.                      KEY G.
{|d :r.m|s :l |s :fe|s :—|ˢd :f |m :d }
{|r :m.r|d :— |ᵈs:f |m :d |r :m |d :— ||
```

Transposition in Sol-fa notation is performed simply by changing the name of the key at the beginning of the piece:

```
  KEY F.
{|d :r |d :f |m.f:s |r :m |d :— |— : ||
  KEY C♯.
{|d :r :d :f |m.f:s |r :m |d :— |—:— ||
```

Mental Effects.—Each note of the scale has a characteristic quality of its own in relation to the other notes of the same scale, and creates an emotional effect different from that of every other note. The following is a scheme of the notes of the scale, giving each its technical name and its peculiar mental effect.

Tonic	Doh^{1}	The Strong or Firm.
Leading Note	Te	The Piercing or Sensitive.
Sub-Mediant	Lah	The Sad or Weeping.
Dominant	Soh	The Grand or Bright.
Sub-Dominant	Fah	The Desolate or Awe-inspiring.
Mediant	Me	The Steady or Calm.
Super Tonic	Ray	The Rousing or Hopeful.
Tonic	Doh	The Strong or Firm.

The above mental effects are those given by Mr Curwen in his *Musical Theory*, and are what he calls the "proximate effect of the tones when sung to a slow melody."

THE BEAUTIFUL IN MUSIC

Art in any of its forms is a fleeting, evanescent thing, which eludes clear and complete definition. When St. Augustine was asked what poetry was in its essence, he replied, "When you ask me, I don't know; when you don't ask me, I do." So is it with music. To say what music is,

where its beauties lie, and in what its charms consist is frankly impossible; but each one knows within himself what he means by the term music, even what he feels to be good music, though he cannot find adequate words to express his thoughts.

Everyone will allow that there are degrees of excellence in music, as in all things in this universe. Burns's *Daisy* is greater poetry than a Bon Gaultier Ballad, and Handel's "Largo" expresses depths of emotion untouched by Sullivan's "Lost Chord." There is something inherent in the music itself that gives it this distinction; it is something quite apart from association with words, place, or instrument that achieves this. Perhaps everyone will not feel this, and allowance must be made for the individual, his training, and state of musical culture. Only by living in the company of good music, and by becoming intimate with the best works of great composers, can sound musical taste be attained. Yet it is not a matter of comparison; for the soundest musical opinions are only possible when there is catholic sympathy with music of all schools, a lively understanding of musical means and conventions, and a willingness to apply an unbiased judgment to music written in an unfamiliar idiom. Good music can be felt rather than reasoned about, and is often recognised instinctively: but the surest guides to show us what is good and what is poor in musical literature are those musicians who have lived in an atmosphere created by music of the highest order.

Melody.—The basis of all music is melody; the use that is made of melody is often nothing but good art, skilful invention, and cunning ingenuity. Melody is to music what dogma is to religion, what language is to thought. It is the material upon which the musician exercises his muse, and is often the result of pure inspiration. Where a fine melody comes from, how it is conceived, and what its constituent parts are, come under the wing of philosophic inquiry, but no aesthetic philosopher has solved these queries yet. Nevertheless melodies may be perfected by skilful workmanship: the note-books of Beethoven show how he collected melodies for his symphonies, some of them in a crude state, and gradually worked them up into a finished and perfected beauty. But the creation of fine melody is the essence of musical genius. Where did the wonderful melodies of Schubert come from? how did they attain their perfect form and suitability? and what process produced them in their unrivalled appropriateness with such rapid succession? Melody flowed from his pen as it did from Mozart's.

Melodies may express every phase of emotion. There is the grave nobility of Handel's "Largo," the love-laden lyricism of Walter's song in *Meistersinger*, the exhilarating charm of the airs in Beethoven's Seventh Symphony, and the melancholy pessimism of themes in Tschaikowsky's Pathetic Symphony. Every melody is significant of some emotion, and it is the justness of its quality to the implied emotion which determines the merit of the music. It is not hard to find bald themes, which are meaningless, as it is also easy to find themes rich in emotion and fully expressive. It has to be remembered that harmony (*i.e.* the distribution of sounds in union with each other) came very late in the history of music, and the earliest melodies were imitations of the inflexions of the voice. Hence, at first, music (*i.e.* melody) was formless, not being limited by any condition of key, form, or rhythm. But what we know as a melody to-day is a succession of notes grouped together by certain relations of key and the recurring accent which we call ryhthm. Broadly speaking, melodies of a slow *tempo* suggest graver ideas and signify the deeper emotions, while tunes of quicker *tempo*, prompting physical movements ranging from simple bodily swayings to the wild gyration of the dance, are associated with the gaiety and more ecstatic side of life. Between the extremes of excessive melancholy and frenzied joy, every grade of emotion may be signified by melody.

Form.—But the human ear has great difficulty in seizing and retaining the succession of sounds which we call a tune. Concentration is needed to absorb even a simple air at a first hearing; so the repetition of a tune is necessary. The repetition of a theme is plain to the least musical person. An examination of "Home, sweet Home," will show anyone what is meant. Schubert seemed to love his own melodies so much, that his many repetitions hint his unwillingness to part with them. This necessity for repetition of melodies, rather than the creation of new ones, has led to what is known as Musical Form. Long practice taught men that repetitions were more effective in some ways than in others. This gradually crystallised into the laws of Form, which laws are derived from the discoveries of the great masters. From the simple distribution of melodies in a short piece, the laws of Form have enlarged their boundaries and have a very wide application. But the essence of musical Form is the effective repetition of melody. In the Rondo, the chief air is returned to over and over again in a very obvious manner (hence the name of this kind of music), and in the Sonata, the repetitions are made with more elaborations and relevance. The Fugue, and other contrapuntal forms based upon weaving two or more melodies, are also reduced to rule to obtain balance of parts, symmetry of structure, and clear development. The nearest parallel is architecture, and the great musical works are built with the same high qualities of design and solidity that distinguish a great edifice. In a well-constructed piece of music,

every musical theme has a value for its own sake and also for the contribution which it brings to the general scheme.

Again, there must be no vain repetitions even of a fine air. This only wearies the ear and weakens the force of the phrase. The great composers were experimenters in one direction and true explorers in another. Haydn fixed the form of the Symphony through his experiments with the Esterhazy orchestra. The simple experience that after the excitement of a quick movement, the ear welcomes the relief of a soothing, slow section, dictated what came to be known as Sonata Form. So, repetitions, once recognised as necessary, must be made with variety. The original theme may be associated with others in combination, it may be repeated in various parts of the scale and in different keys, it may be subjected to variations or be treated in time and rhythm according to the skill of the composer. Just as a speaker takes a subject or definite argument and by playing upon it with his wit, his powers of exposition, skill of illustration, ornament, or emphatic incision, drives home his point of view by the studied variety of his treatment, so the composer takes a musical phrase and moulds it to his fancy, presenting it in different lights and shades until his hearers are thoroughly familiar with its features. Herein lies great art, and, apart from the themes themselves, nowhere is the greatness of music found more strikingly than in the manipulation of musical themes.

This treatment of themes, such as is found in a symphony, a sonata, or a concerto, does not depend upon complexity, for complexity need not be profundity. Some of the greatest music is very simple: Schumann's "Lotus Flower" is as perfect a gem in its way as the Ninth Symphony. It is the logical treatment, the inevitable nature of the development, such as in literature we find in Shakespeare, that makes great music what it is. But many other elements go to the creation of great music. In orchestral music, for instance, there is the skill in combining instruments to provide what is commonly known as orchestral "colour." The rich, barbaric orchestration of Tschaikowsky and the delicate, tingling orchestral scoring of Debussy are wonderfully different things, but each is good because appropriate to its purpose. Chords which sound well with one set of instruments do not sound well with another combination, and chords which are agreeable in one position may be positively disagreeable in another. So in purely technical matters, much knowledge, discretion, and a clear notion of the purpose in hand are necessary in all sincere musical effort.

Originality.—Ben Jonson said that in beauty there must be an element of strangeness. He meant this to apply to literary—probably poetic—beauty, but it is true of all beauty, including musical beauty. With him strangeness means unfamiliarity—individuality, perhaps—distinguishing character, certainly. It is the quality which lifts a musical composition out of the common, and removes it from being based upon a stock pattern. The composer's ingenuity and originality find scope here, and it is the freshness of his ideas that gives him his niche in the Temple of Fame. A composer with limited originality is apt to let his favourite devices become mere mannerisms, and, unless he has wide imagination, he will drop out of the race. Every great composer has his imitators, and mere imitation of good work is never in the first rank. Of course Field wrote nocturnes before Chopin, who, in his turn, beat his predecessor on his own ground; but how many nocturnes by Chopin's successors have life to-day? Staleness is fatal in art; the artist must have something new to say, as well as something permanent. Yet there is no rule for the excellence of music.

There are three elements inherent in music—the sensuous, the intellectual, and the emotional. All of these are present in every piece of music, but in varying proportions, and it is according to the proportion that the music has its distinguishing character.

The sensuous element appeals to the ear alone, and, when it predominates at the expense of the other two, we get music on a low plane. Piquant music, with tricky rhythm, and sickly sentimental drawing-room ballads often belong to this class. The ear is tickled, and the unintelligent listener is often content to have his senses pleasantly stimulated, but such music is evanescent. It is musical confectionery; its cloying sweetness soon wearies us, and the predominance of sensuousness oftens answers the question, "Where are the songs of yesterday?" For most people have had the experience of being obsessed by a sentimental tune which haunts the brain until it becomes hateful. Less catchy tunes have more lasting merits; they have wearing qualities, like the wedding garment of Mrs. Primrose. Music which makes no demand upon the intellect, which does not express a true emotion, or which has not the stuff of life in it, cannot live. Clever and piquant orchestration often disguises poverty of musical ideas, and the organ tones of a popular contralto may make a poor song sound like fine music; but the attractive performance of poor music can only ensure it an ephemeral success.

But the sensuous element must be present in all music—it is its predominance that is fatal. It must be confessed that the majority of folk are content to judge music by the effect it has upon their ears. Music of any worth must also appeal to the intellect, and may do so in several ways. Probably the chief of these is through its form. Here the trained ear is

quick to recognise the formal excellencies of a piece of music, and is not easily led away by purely sensuous prettinesses.

The intellectual element is found most prominently in those works like the Symphony Fugue, Sonata, Concerto, &c., wherein the highest characteristics of design are to be found. These are called the Classic Forms, and these forms govern the composer's method of treatment. They place limits upon his use of materials just as rhythm and versification generally circumscribe the range of the poet's technique. In the case of the Romantic school, however, it is the fancy that governs the form, and the themes, which are to music what ideas and concepts are to literature, are developed or left undeveloped and fresh ones employed—not according to rule, but according to the arbitrary moods of the composer. There is always musical form in the works of the Romantics, but it is a different form from classic form.

Classic and Romantic.—The terms Classic and Romantic are used so loosely that they have been the subject of endless discussion. The two terms are not really opposites, and works like the Beethoven symphonies may very well be claimed under either head. Classical works may be regarded as those which pay strict attention to established forms, and use accepted masterpieces as their models; but there is another sense in which the term is used. Classical works are often taken to mean those compositions which in the general opinion of musical authorities are on the highest plane of artistic achievement. To adapt a Ruskin phrase, they are the "music of all time." But this would include much music of the Romantic School. This brings us once more to the question of musical form, and it is perfectly safe to say that the musician using the sonata, fugue, and symphony for his models, and paying strict attention to those rules deduced from the best examples of these, will be working on classical lines. Romantic music makes less of form, demands freedom and elbow room, is richer, more highly coloured, and inclined to venture experimentally into regions where classical music, from its very nature and limiting conditions, cannot enter. Attention to form, a dignified restraint, something approaching austerity, and economy of means will be found in all music of the Classical School. But in the end, the Romantic of to-day is the classic of to-morrow, and although the terms are useful for the purpose of differentiation, they require careful discrimination and definition.

The emotional element is no less prominent in all good music. Music expresses moods, but, as has been well pointed out, it does not express the cause of moods. Thus music follows the laws of nature. For instance, an emotion like grief is expressed by minor intervals and by chromatic passages, for observation shows that the voice employs similar means to these in expressing sorrow. Similarly a staccato phrase suggests agitation, and a legato passage indicates sometimes calmness of mind. Beethoven was the first to give adequate expression to emotional utterance through music, and in his works rage, humour, passion, and grief are all revealed to the attentive listener. The emotional element is strongly evident in the music of the Romantic School, where restlessness and passion are prominently depicted. Especially is it present in song literature, where the function of music is to intensify the significance and idea of the verses. Even humour may be portrayed in musical terms. The boisterousness of Strauss's *Till Eulenspiegel* reflects the character of that merry scamp; Beethoven poked some rare fun at the village band in the Pastoral Symphony, where the wood winds play amusing cantrips. The bassoon can be made the clown of the orchestra, though this is a lower form of humour. Sullivan's share in the success of the Savoy operas was quite as great as Gilbert's, and the neatness of his orchestral writing and characteristic quality of his melodies in association with humorous verse have quite a wit of their own, which an admiring public has, quite unconsciously, appreciated.

All great music is sincere. It is rich in ideas which are worthy in themselves; some kind of musical form must be apparent to provide proportion, balance, and symmetry of construction, and it must appeal to heart and head as well as to the ear.

A COURSE OF READING

Outside the band of professional musicians, the great majority of listeners to music never dream of reading about the art which gives them great and lasting enjoyment. How often do we hear a real music-lover say, "I know what I like," after which he either leaves the discussion at that or, still worse, proceeds to argue without even a pretence to knowledge. He hears the Pathetic Symphony, and, although he is ravished with it, cannot tell the sound of the bassoon from that of the oboe. He does not like the music of Debussy and Delius because their music is in an unfamiliar idiom, and he proceeds to condemn the innovators.

It is the object of this Course of Reading to suggest a line of study which will help the general reader to follow a Beethoven Symphony with greater understanding, will put him in the way of finding out for himself wherein good playing and singing consist, and will, if pursued, place him in touch with a branch of literature capable of giving music, in all its aspects, quite a new meaning.

The study of musical biography is no despicable thing, though it must not stop at Wagner's

amours or Handel's splenetic outbursts. To know the man is to have a better understanding of his music, and to know a composer's intentions is to find a delight in his works far removed from the mere ear-tickling sensations which often satisfy the average listener.

The subject of music is very much subdivided, and, in beginning the study of any special division of the art, it is well to start with one of the smaller manuals giving a general conspectus of the branch of music under review. From the very first, the student should have access to Grove's *Dictionary of Music.* If he does not possess a copy, he should join a library where the dictionary may be found. It is really an encyclopædia of music, and deals fully and at length with every branch of the musical art. In it every musician has his biography told and his works classified and criticised; all varieties of musical form, as fugue, sonata, and symphony, are treated historically and descriptively with illustrations. Musical instruments, ancient and modern, are explained—in fact, there are few even obscure points which this invaluable work does not discuss, and every one of its articles is by a competent authority. There are three editions: the first, edited by Sir George Grove, is full of useful matter; the second is the first amplified under the editorship of Mr. Fuller Maitland, and has a most useful index; and the third, brought up to date under the same editor, is extended to five volumes, and is complete in its up-to-date attitude and material. Of course, such a work is purely a book of reference. Other dictionaries which are on a smaller scale and have real value for students, are *A Cyclopædic Dictionary of Music*, by Ralph Dunstan, and the *Biographical Dictionary of Musicians*, by W. H. Cummings.

HISTORY OF MUSIC

General.—A study of the history of music is of more value than many practical musicians will allow. No one can criticise the music of to-day without some knowledge of the music of the past. Debussy's revival of the old scales and Richard Strauss's development from an orthodox to a revolutionary musician are only comprehensible to one who knows his history. Further, there is no more wonderful growth in art than the extraordinary evolution of the great orchestral and choral compositions from the simple germ which gives them their origin. A very good outline of the growth of the musical art is found in either *The Story of Music*, by Crowest, or *How Music Developed*, by W. J. Henderson. Both are written in a fairly popular style, and avoid the use of cumbrous technical nomenclature. With this general view of the subject, the student should proceed to the more detailed *Summary of Musical History*, by Sir Hubert Parry, a book packed with reliable information and sound judgments, and he should follow this with the same author's *The Evolution of the Art of Music.* Every page of the latter book repays careful reading for its comprehensive treatment of the development of music as an art and of the influence of great composers upon the trend of music generally. More detailed treatment of the subject will be found in the older histories of Burney, Hawkins, and Naumann, but the advanced student will find in the *Oxford History of Music*, edited by W. H. Hadow, the most complete and up-to-date account of the history of the art from the Middle Ages up to the nineteenth century.

The Early Period.—The student who wishes to make an exhaustive study of the history of music and is interested in its early beginnings, will find *The Music of Most Ancient Nations*, by Carl Engel, indispensable for his purpose. It deals with the music of the Assyrians, Egyptians, and Hebrews, with a full discussion of early records of music and ancient instruments. *The World's Earliest Music*, by Hermann Smith, is specially valuable for its description of old instruments among Eastern races. The subject is treated succinctly and in shorter space in the early chapters of Dr. Ritter's *Manual of Musical History*, and, for examination purposes, the *Chronometrical Chart of Musical History*, by C. A. Harris, is not without service at this stage.

The Mediæval Period.—The first six sections in the article "Schools of Composition" in the first edition of Grove's *Dictionary* will give a general view of this period, when music was mostly of an ecclesiastical nature. It is much more fully treated in the first volume of *The Oxford Dictionary*. The article on the "Mass" in Grove's *Dictionary* also bears upon the subject: any life of Palestrina, as Felix's, will add to the study of the period. *Great Musicians*, by E. Oldmeadow, has some good chapters on early church music. Secular music of the period will be found under "Troubadours" and "Song" in Grove's *Dictionary*. The influence of the Church upon the joint development of notation and harmony is admirably treated in *The Rise of Music*, by Joseph Goddard, the illustrations of which are excellent on this part of the subject as upon others.

Early English Music.—The sixteenth and early seventeenth centuries were notable for the luxuriant growth of music on English soil. Frost's *Church Music*, and *Our Great Church Composers*, by E. Done, treat the ecclesiastical side with knowledge and insight. Chappell's *Popular Music of the Olden Time* is a mine of information. There is much of value in *The Story of Minstrelsy*, by Edmonstone Duncan; and Dr. Naylor's *Shakespeare and Music*, besides a fine introductory chapter, contains much excellent matter on the music of the period. *English Music*, a delightful collection of lectures

in the Music Story Series, is full of interesting information. In it, church music, popular music, the various instruments then in use, forms of vocal music, favourite dances, masques, and the music of the wayside are written about with much understanding and fullness. The later seventeenth century is well treated in Cumming's *Life of Purcell*. The typical form of English music at this period was the madrigal and glee, and this subject may be best studied in the compact and complete volume by W. A. Barrett, named *English Glee and Madrigal Writers*. The publications of the English Madrigal Society—which have factful introductions—ought to be consulted, and a first-hand study of the music of the Elizabethan times may be had in Dr. Rimbault's edition of the famous *Parthenia*.

Seventeenth and Eighteenth Centuries.—The articles on "Opera" and "Oratorio" in Grove's *Dictionary* will serve as an introduction to this period, while the period from Handel to Beethoven can be best studied in the lives of the composers of the period.

Nineteenth Century.—This great productive and creative period is capably surveyed in Elizabeth Sharp's *History of Music in the Nineteenth Century*. The latter chapters of Dr. Ernest Walker's *History of Music* are written from the modern attitude. *English Music in the Nineteenth Century*, by Fuller Maitland, is an appreciative record of English musicians during the century before Elgar and his compeers took possession of the field. One of the chief features of modern musical developments is discussed from its earliest beginnings to the present day in Professor Niecks' *Programme Music in the Last Four Centuries*.

Modern Music.—The very latest developments of musical composition are thoughtfully considered in *Living Music*, by Herbert Antcliffe; Ernest Newman's *Musical Studies*, Lawrence Gilman's *Phases of Modern Music*, the same author's *The Music of To-morrow*, and the series of monographs, *Living Masters of Music*, will provide a fairly complete picture of contemporary musical life, and will show the trend of the modern composers and their aims. One of the best guides which the student of musical history can consult is *The Growth and Development of Music*, by Edward Dickinson. In it the author has given, in separate chapters, a short and concise description of each stage in the development of music, and, at the close of each section, has provided a bibliography of all the best commentaries written in the English language. As a history the book is a sound and reliable authority; as a bibliography, it is invaluable.

Biographies.—The enjoyment of music is greatly enhanced by some knowledge of the lives and personalities of the composers. It is no unworthy thing to seek to find the man in his music, and practically every musician of importance has had his biographer. *Great Musical Composers*, by Ferris, is anecdotal and lively, and *Master Musicians*, by Cuthbert Hadden, has popular features. Parry's *Studies of the Great Composers* is largely biographical, and its critical sections are written "without touching the profounder and more abstruse sides of the musical art." There are several admirable series, treating all the great musicians. Bell's Miniature Series of Musicians is a set of short and handy biographies; *The Master Musicians*, a series issued by Dent, treats the lives and works of composers with considerable fullness, and the "Great Musicians" Series is no less valuable. For special musicians the following books should be read: Spitta's *Bach*, *Beethoven* in Grove's *Dictionary*, Niecks' *Chopin*, Rockstro's *Handel*, W. H. Hadow's *Haydn*, Moscheles' *Mendelssohn*, Jahn's *Mozart*, *Schubert*, by Sir G. Grove in the *Dictionary of Music*, Niecks' *Schumann*, *Tschaikowsky* in Mrs. Newmarch's translation of Modeste Tschaikowsky's life of his brother, and *Wagner* in the lives of that interesting musical personality by Präger, Ernest Newman, and Dannreuther.

MUSICAL THEORY

As an introduction to the study of the theory of music, Ralph Dunstan's *A Manual of Music* sets forth sol-fa and staff notations in an easily-comprehended manner. The notations may then be studied separately and with greater fullness in *The Rudiments of Music*, by W. H. Cummings, for the staff notation, and in John Curwen's *Tonic Sol-fa*. An interesting account of the rise of the notations is found in C. F. Abdy Williams' *The Story of the Notations*.

Harmony, Counterpoint, Form, and Composition.—The rigid rules and pedantic inhibitions of the older school of harmony and counterpoint have been ruthlessly treated by the moderns, but it should be remembered that these rules were the results of experience and experiment, and that the iconoclasts of to-day were all thoroughly grounded in these rules before they proceeded to break them. George Oakley's *Text-Book of Harmony* is clearly and simply written, and Clarence Lucas's *The Story of Musical Form* is a useful introduction. Ebenezer Prout's *Harmony* is still a standard work; *The Fugue*, by Prout, is invaluable for its collection of examples from classical sources, and in the same author's *Musical Form* the fundamental principles of the subject are discussed. Pearce's *Student's Counterpoint* is a useful work. For the evolution and growth of the Symphony, Sonata, Concerto, and Overture, the student is recommended to the articles on these subjects in Grove's *Dictionary*, where they are treated in a masterly way. Parry's *Evolu-*

tion of the Art of Music has some good chapters on the Symphony and Sonata.

The modern aspect of harmony and the allied branches of the musical art will be found in Stewart Macpherson's *Practical Harmony*, in *Form in Music* by the same writer, and in *Musical Composition* by Sir Charles Stanford—the latter a work of true modern sympathies and written by a composer of high standing. The student who is puzzled by the composition of modern masters will find *Modern Chords Explained*, by Arthur G. Potter, a book to lighten his darkness.

The Orchestra.—The great popularity of orchestral music to-day has led to an increased interest in the units of this mighty combination of players. *The Orchestra and Orchestral Music*, by W. J. Henderson, and *How to Listen to an Orchestra*, by Dr. Annie W. Patterson, are books for amateurs with all the instruments described and the art of conducting explained. *The Orchestra, and How to Write for It*, by Fred Corder, is a practical treatment of the subject, and John Fitzgerald's *Modern Instrumentation* is, as its title suggests, written from the point of view of later composers. The more advanced student should study *A Treatise on Modern Instrumentation*, by Berlioz, one of the few great composers to write upon his own subject, and the two volumes by Prout on *The Orchestra*. Under this head, note should be made of Grove's *Beethoven and his Nine Symphonies*, an exhaustive study of the great master's methods, intentions, and material. For a full study of the constitution of the orchestra, *The Instruments of the Modern Orchestra and Early Records of the Precursors of the Violin Family*, by Kathleen Schlesinger, is an authority of great importance. It is in two volumes and practically exhausts the subject.

Singing and the Voice.—*The Art of Singing*, by W. J. Henderson, contains many hints of practical value. *Voice, Song, and Speech*, by Lennox Browne and Emil Behnke, is a notable practical guide by a surgeon and a voice-trainer in collaboration. *The Art of Singing and Vocal Declamation*, by Sir Charles Santley, contains much excellent advice by the veteran baritone, but some of it is anti-modern in its tendency. *The Singing of the Future*, by Ffrangçon-Davies, is unusually interesting to singer and musician, and *Interpretation in Song*, by H. Plunket Greene, is a vigorously-written book showing how to make the most of the meaning of both words and music of a song.

Oratorio and Opera.—*The Story of Oratorio*, by Dr. Annie W. Patterson, tells succinctly the growth of oratorio from early times to the present day. The article on "Oratorio" in Grove's *Dictionary* is full of information, and any of the standard lives of Handel, Haydn, and Mendelssohn, along with Fuller Maitland's *English Music of the Nineteenth Century*, will cover the ground until Elgar's day. Elgar's *The Dream of Gerontius*, is epoch-making in its method, and for the modern development of oratorio and choral work the student should read either Buckley's or Newman's life of Elgar.

As for **opera**, a good conspectus is found in R. A. Streatfield's *The Opera*, or the article in Grove. The *Life of Weber*, by Benedict, and Newman's *Gluck and his Opera*, are valuable for special features of operatic development. Wagner opera is a thing by itself, and the literature about it is endless. The legends upon which the *Nibelungen Ring* is founded may be studied in *Stories from Wagner*, by J. W. M'Spadden, *The Story of the Ring*, by O. Kramer; or *The Wagner Stories*, by Filson Young. *Wagner*, by C. A. Lidgey, gives not only Wagner's life, but a full explanation of the aims, artistic and musical, of the composer. Ernest Newman's *Wagner* provides a sane criticism of the man and his works, gives a synopsis of the series of operas, and is specially valuable in setting forth the leading themes of each part of the tetralogy.

The more recent development of opera in the hands of Strauss, Debussy, and Puccini are fully discussed in Ernest Newman's *Richard Strauss*, in Laurence Gilman's *Salome*, in Lieblach's *Claude Debussy*, in Daly's *Debussy*, in Wakeling Dry's *Giacomo Puccini*, and in Laurence Gilman's *The Music of To-morrow* and his *Aspects of Modern Opera*.

The Opera Problem, by J. W. Galloway, discusses opera as a national institution from the practical point of view.

Critical and Æsthetic.—A beginning to the study of music on the æsthetic side may be made with W. J. Henderson's *What is Music?* in which discussion is raised as to wherein musical beauty is found and of what intellectuality, thought, and emotion in music consist. *The Beautiful in Music*, by Ernest Pauer, is a short work which seeks to find the laws governing the construction of a perfectly-beautiful musical work of art. Professor Hand's *Æsthetics of Music* treats the subject exhaustively, and the student may be warmly recommended to *Music, its Laws and Evolution*, by Combarieu. Parry's comprehensive *Style in Musical Art* deals with form, texture, colour, and other æsthetic aspects of music. *The Physical Basis of Music*, by A. Wood, is an exceedingly helpful little volume which expounds in lucid terms the scientific side of music and throws some light on the æsthetic side as well. This side of music is fully treated in Helmholtz's *Sensations of Tone*, and in the articles on "Ear," "Music," and "Sound" in the *Encyclopædia Britannica*.

There is a considerable library of books of a critical and general nature. These are usually collections of articles, already printed in the higher-class magazines or musical papers, and some contain critical essays of high value. They

really come under the head of general reading, and, as such, can hardly be classified. Their value frequently lies in the light they throw upon the current opinions and controversies of the day. A few of such books are *Music and Musicians*, by E. A. Baughan; the clever and entertaining *Diversions of a Music-Lover*, by C. L. Graves; *Master-Singers*, and *More Master-Singers*, by Filson Young—two volumes on musical interpretation, the latter containing a specially charming and literary article on life in an English cathedral of to-day; Siloti's valuable *Memoires of Liszt*, and Ernest Newman's *Musical Studies*. *Modern Tendencies and Old Standards in Musical Art*, by A. J. Johnstone, contrasts the state of things of yesterday and to-day in the musician's progress. *The Future of Music*, by Mrs. Franz Liebich, treats of the changes in scale and other aspects of the art which are now in the melting-pot. Literary charm and keen modern sympathies stamp the *Mezzotints in Modern Music*, by John Huneker, and the profound study of Joseph Goddard in his *The Deeper Sources of the Beauty and Expression of Music*, will teach the student much regarding the very stuff of music, and incidentally why most music in time becomes *démodé*. Pianists will learn much in *Beethoven's Pianoforte Sonatas* as explained by Ernst von Elterlein. They will understand Chopin better if they read Kleczynski's *Greater Works of Chopin*. *The Music-Drama of the Future*, by Rutland Boughton and Richard Buckley, describes the aims and views of two ardent musicians of the younger school; and *The Symphony-Writers since Beethoven*, by Weingartner, is a stimulating and thoughtful treatise for music-lovers of every grade by one of the really great conductors of the day.

H. M. Willsher.

VI. MATHEMATICS

ARITHMETIC AND ALGEBRA

In studying any subject certain things must be taken for granted. In Chemistry we accept without doubt the fact that elements exist; in Painting we accept the idea of definite colours; in Music we accept the idea of definite sounds. So in Arithmetic we accept the elementary unit 1 (Latin, *unus* = one). Similarly, we accept the idea of 3 units. Ask a schoolboy what he means when he says 3; it is unlikely that he will reply, "I mean 3 units." Ask him what he means when he says 3 apples, and he may be wise enough to answer, "1 apple and 1 apple and 1 apple." 1 is an abstraction; 1 apple is a concrete fact. We advise the student to be concrete; when we write 1 he should think of 1 *thing*—an apple, a pie, a motor-car—anything.

What do we mean when we say 16 apples? We might reply, "1 apple and 1 apple and 1 apple," &c., or we might say, "10 apples and 6 apples."

What do we mean by 16? We mean 10 units and 6 units. Similarly, 49 means 40 units and 9 units, or, as it is usually written, 4 tens and 9 units. The number 672 means 600 units and 70 units and 2 units, or 6 hundreds and 7 tens and 2 units. When we say an army consists of 4719 men, we may think of it as containing 4000 men and 700 men and 10 men and 9 men, or 4 thousand men and 7 hundred men and 10 men and 9 men.

The number 1,000,000 is called one million. There are three spaces $\boxed{1\,|\,000\,|\,000}$; the mid-space holds the thousands. If we have to write 4 millions 900 thousands, we have $\boxed{4\,|\,900\,|\,000}$. If 6 millions 30 thousands, we write $\boxed{6\,|\,030\,|\,000}$. If 7 thousands, we have $\boxed{0\,|\,007\,|\,000}$. Make commas denote the space divisions. Thus seven millions, two hundred and sixty-four thousand, one hundred and forty-two is written 7,264,142. Note the value of each figure:

7 millions are	7,000,000
2 hundreds of thousands are	200,000
6 tens of thousands are	60,000
4 thousands are	4,000
1 hundred is	100
4 tens are	40
2 units are	2

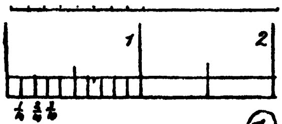
Write the number seventy-four million, two hundred and four. Mark off your three spaces thus: $\boxed{\text{millions}\,|\,\text{thousands}\,|\quad\quad}$. The 74 millions go into the first space, the thousands into the second. Read the number and you find there are *no* thousands; fill the thousand space with three noughts. The last space holds the 204. The number is therefore written, 74,000,204. We could write four thousand, nine hundred and twenty thus, 0,004,920, but the noughts on the left are unnecessary, hence we write it 4,920. Large numbers are seldom heard of in everyday life. We occasionally read about millions of pounds—for example, we read that Britain spent £42,858,000 on her Navy in 1911–1912; or we read that the population of England and Wales was 36,075,269 in 1911.

It is difficult to *realise* large numbers. If we read that a fixed star is 9,164,271,000,000,000,000 miles from the earth, we cannot realise what distance this number represents.

We count by tens, possibly because we have ten fingers. The word "sixteen" is really six-ten; thirty is three-tens. The manager of a theatre when counting the people in the stalls counts by tens; whenever he counts ten people he presses a button on a portable register. Later his register shows how often the button was pressed; if 36 times, there were 360 stallholders. If a shilling were 10 pennies, and a pound were 10 shillings, shopping would be easy; 3/6 would be 36 pennies, 5/7 would be 57 pennies, and so

on. Counting by tens is known as the *Decimal System* (Latin, *decem* = ten).

Let us return to the apple. Take a knife and divide the apple into two equal parts. Each part is called half an apple. Now we are dealing with *parts* of an object, or, as they are called in Mathematics, *fractions* (Latin, *fractum*, broken). A fraction, therefore, is a bit broken off. If we divide the apple into four equal parts each part is a quarter or a fourth part, written thus, $\frac{1}{4}$ of an apple. Evidently there are 4 fourths ($\frac{4}{4}$), or 2 halves ($\frac{2}{2}$) in an apple. If you could divide the apple into 10 equal parts (a difficult task) each part would be a tenth ($\frac{1}{10}$) of an apple, and the whole apple would contain 10 tenths ($\frac{10}{10}$) of an apple.



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Consider the part of a penny ruler in Fig. 1. The first inch is divided into ten equal parts (tenths). Half an inch clearly contains 5 tenths ($\frac{5}{10}$). Fractions such as $\frac{1}{2}$, $\frac{1}{10}$, $\frac{4}{10}$, $\frac{9}{10}$, $\frac{1}{6}$, $\frac{5}{6}$, &c., are known as as VULGAR FRACTIONS, that is, *Common Fractions*. Tenths may be written in another way. One-tenth ($\frac{1}{10}$) may be written as "decimal one" (·1), $\frac{2}{10}$ as "decimal 2" (·2), $\frac{5}{10}$ ($=\frac{1}{2}$) as "decimal 5" (·5), and so on. $\frac{1}{10}$ is a Vulgar Fraction; ·1 is a Decimal Fraction. $4\frac{1}{10}$ apples may be written as 4 apples and ·1 of an apple, or 4·1 apples. $4\frac{1}{2}$ apples are 4·5 apples. Think of the number one hundred and eleven (111); it is 1 hundred and 1 ten and 1 unit. Now take $111\frac{1}{10}$ apples, that is, 111·1 apples; the number on the left of the point refers to whole apples, but the number on the right of the point refers to a fraction or part of an apple.

If we divide an apple into 100 equal parts each part is a hundredth of an apple ($\frac{1}{100}$); in decimal notation this is written as ·01 of an apple. One thousandth part ($\frac{1}{1000}$) is written as ·001; one ten-thousandth part ($\frac{1}{10000}$) as ·0001. Now let us value each figure in the number 1234·56978. 1234·56978 = 1 thousand, 2 hundreds, 3 tens, 4 units, 5 tenths, 6 hundredths, 9 thousandths, 7 ten-thousandths, 8 hundred-thousands, or

$$1234{\cdot}56978 = 1{,}234 + \frac{5}{10} + \frac{6}{100} + \frac{9}{1000} + \frac{7}{10000} + \frac{8}{100000}$$

Questions:

(1) What is the value of the figure 4 in the number 249?

Answer, 4 tens.

(2) What value has the figure 6 in the number 6,016,432·062?

Answer. The first 6 represents 6 millions, the second 6 thousands, the third 6 hundredths ($\frac{6}{100}$).

(3) What do you mean by ·2 of a pie?

Answer. The pie is divided into 10 equal parts, and any 2 parts are taken. These two make 2 tenths of a pie, and the fraction can be written as $\frac{2}{10}$, or ·2 of a pie.

(4) How many eighths are in an inch?

Answer, 8 eighths, or $\frac{8}{8}$.

How many in half an inch?

Answer, 4 eighths, or $\frac{4}{8}$.

(5) How many sevenths are in an orange?

Answer, 7 sevenths, or $\frac{7}{7}$.

How many in half an orange?

Answer. The half of 7 sevenths, that is, $3\frac{1}{2}$ sevenths, or $\frac{3\frac{1}{2}}{7}$.

(6) What is a threepenny bit?

Answer. A silver coin worth 3 pennies.

1 threepenny bit = $\frac{1}{2}$ of sixpence.
= $\frac{1}{4}$ of a shilling.
= $\frac{1}{10}$ of half a crown.

(7) Can 3*d*. be written as a decimal fraction?

Answer. Yes. 3*d*. = $\frac{1}{10}$ of a half crown.
= ·1 of a half crown.

(8) What is the value of ·9 of a half crown?

Answer. ·1 is $\frac{1}{10}$; $\frac{1}{10}$ of a half crown is 3*d*.; ·9 is $\frac{9}{10}$. Therefore ·9 of a half crown = $\frac{9}{10}$ of a half crown = 9 threepences = 27 pence = 2/3.

ADDITION

Sign of addition is "plus," written thus +

The sign = means "the same as," and is spoken of as "equal to."

If we add 2 to 6 we can place one figure beneath the other, thus:

$$\begin{array}{r} 2 \\ \underline{6} \\ 8 \end{array} \qquad \text{or} \qquad \begin{array}{r} 6 \\ \underline{2} \\ 8 \end{array}$$

We can also write the sum thus: 2 + 6 are equal to 8, or 2 + 6 = 8, or 6 + 2 = 8. In adding units we have no difficulty. In the sum 2 + 4 + 9 + 7 + 6 we simply say 2, 6, 15, 22, 28. But consider the following sum:

$$\begin{array}{r} 46 \\ 12 \\ 24 \\ \underline{32} \\ \underline{\underline{114}} \end{array} \qquad \text{or} \qquad \begin{array}{r} 40+6 \\ 10+2 \\ 20+4 \\ \underline{30+2} \\ \underline{\underline{100+14}} \end{array}$$

We do not begin "32 and 24 make 56, 56 and 12 make 68, &c." We add the units 2, 4, 2 and 6, and get 14 units; we add the tens 3, 2, 1 and 4, and get 10 tens. Our answer is thus 10 tens 14 units. But 14 units = 1 ten + 4 units. Hence the sum = 10 tens + 1 ten + 4 units.
= 1 hundred + 1 ten + 4 units.

In practice we "carry" figures from the unit line to the ten line, from the ten line to the hundred line, and so on. The sum of line is 14; we say, "This is 1 ten and 4

we shall put down the 4 under the unit line, and add the one ten to the ten line."

You cannot add dissimilar things. 2 apples +4 apples = 6 apples, but 2 apples + 4 oranges do not make 6 apples or oranges.

Arithmetic is the science of numbers. We now branch off into the allied science of algebra. In arithmetic figures are used to denote numbers; in algebra symbols are used to denote numbers. In arithmetic we write 5 men; in algebra we may write x men, but we must remember that x stands for a number.

The sum $a+b+c+d$ means nothing unless one remembers that each letter stands for a number. Suppose a stands for 3, b for 6, c for 7, d for 9.

$$a+b+c+d=3+6+7+9=25.$$

A farmer buys a cows on Monday and b cows on Tuesday, how many cows has he? Obviously $a+b$ cows.

Now that we have reached symbols, let us return to numeration. Suppose we are told that the digits of a number are a and b. If a is the tens digit, the number is a tens $+b$ units, *i.e.* $10a+b$. If b is the tens digit, and a the units digit, the number is $10b+a$. So if a be the unit digit of a number, b the tens digit, and c the hundreds digit, the number is written $100\,c+10\,b+a$.

Addition of Decimal Fractions.—The beginner knows that 5 plus 6 make 11. He therefore concludes that ·5 plus ·6 make ·11. Let us examine this. ·5 we found to be another way of writing 5 tenths ($\frac{5}{10}$), ·6 we found to be 6 tenths ($\frac{6}{10}$). Therefore $\cdot 5+\cdot 6=\frac{5}{10}+\frac{6}{10}=5$ tenths + 6 tenths = 11 tenths. Now there are ten tenths of an inch in an inch; 11 tenths of an inch therefore make 1 inch and a tenth of an inch, or $1\frac{1}{10}$ inches. Written as a decimal, $1\frac{1}{10}$ is 1·1. Thus the sum of ·5 and ·6 is not ·11 but 1·1. Note the values of each figure; ·11 is $\frac{1}{10}$ of a unit + $\frac{1}{100}$ of a unit; 1·1 is 1 unit + $\frac{1}{10}$ of a unit. Add ·2+·4+·9, and you are really adding 2 tenths + 4 tenths + 9 tenths. The answer 15 tenths is 10 tenths + 5 tenths, or a whole (apple, inch, anything) + 5 tenths (of an apple, inch, anything). But a whole unit plus $\frac{5}{10}$ of a unit is 1·5.

Add ·06+·724+9·622.

Place them thus:

$$\begin{array}{r} \cdot 06 \\ \cdot 724 \\ 9\cdot 622 \\ \hline 10\cdot 406 \end{array}$$

Any schoolboy will tell you that addition of decimals is easy. "Keep your points under each other and you can't go wrong," he may say. But the student must understand every step. Add the 2 thousandths and the 4 thousandths and you get 6 thousandths, that is, ·006 or $\frac{6}{1000}$. Add 2 hundredths and 2 hundredths and 6 hundredths of the second line and you get 10 hundredths ($\frac{10}{100}$), which is $\frac{1}{10}$, or ·1. Add the ·1 to the third line; 1 tenth + 6 tenths + 7 tenths = 14 tenths = 1 unit and 4 tenths. The 4 tenths go down in the answer as ·4 and the 1 unit is added to the 9 units, making 10 units in all.

Add 16+·16+1600+·00162+1,760,216+·0004.

Arranged these numbers read:

$$\begin{array}{r} 16\cdot 0 \\ \cdot 16 \\ 1{,}600\cdot 0 \\ \cdot 00162 \\ 1{,}760{,}216\cdot 0 \\ \cdot 0004 \\ \hline 1{,}761{,}832\cdot 16202 \end{array}$$

·0 is not usually written: we use it in the first line to show how whole numbers are always on the left side of the point. What are the values of the first and last figures of the answer? The first figure 1 represents 1 million units; the last figure 2 represents 2 hundred-thousandths of a unit, that is, ·00002, or $\frac{2}{100000}$ of a unit.

SUBTRACTION

Sign of subtraction is "minus," written thus -

Subtraction means "taking away from," and it is a form of addition. When you say 2 nuts from 5 nuts leave 3 nuts, you are really reasoning thus: "I have to take 2 nuts from 5 nuts; what do I *add* to 2 nuts in order to make 5 nuts?"

There is no difficulty in this kind of subtraction. If we are told to find the difference between 69 and 14 there is no difficulty; we place the numbers thus:

$$\begin{array}{r} 69 \\ 14 \\ \hline 55 \end{array}$$

We subtract the 4 units from the 9 units, and then the 1 ten from the 6 tens. But when we try to subtract 19 from 34 we are into deeper water. Take 5 from 8 and the remainder is 3. This is usually written thus:

8 minus 5 equals 3

or $8-5=3$

Let us add 6 to each of the numbers 8 and 5. The sum now is $(8+6)-(5+6)=3$

or $14-11=3$

If you add the same number to each of two numbers the difference between the two remains the same, $9-2=7$.

Add 19 to 9 and to 2

then $28-21=7$

We return to our problem. How do we find

the difference between 34 and 19? Most of us find it in this way; we place the numbers so:

$$\begin{array}{r} 34 \\ \underline{19} \\ \underline{15} \end{array}$$

and we say, "9 from 4 you can't, but 9 from 14 leaves 5." We have a vague idea that we have borrowed a 1 somewhere, and we "pay it back" by calling the 1 of the 19 a 2. We therefore go on: "2 from 3 leaves 1." The answer is thus 15. Now note what we have been doing. We called the 4 14, that is, we added 10 to the upper line. And when we called the 1 of the lower line a 2 we were adding 10 to the lower line. And, as we saw, the same number added to each line does not alter the value of the difference. Write it thus:

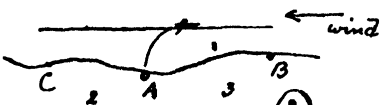
$$34-19, \text{ or } (30+4)-(10+9)$$

Add 10 to each, then we have:

$$(30+14)-(20+9)=10+5$$

We subtracted the 9 from the 14, and then the 20 from the 30.

In algebra we speak about *Positive* or plus, and *Negative* or minus signs. These terms are difficult to define; in general, Positive means the usual, Negative the unusual. When a man climbs a hill the forward path is the positive or usual direction; but every time he slides back a few feet he is going in a negative direction. He does not want to slip back at all.



(2)

Fig. 2 shows three seaside towns, A, B, and C. I row out from A to go to B, a distance of 3 miles. When I get to B a strong wind arises and carries me back to C, which is 2 miles past my home in A. Naturally I am angry; I did not want to go to C, I had an appointment in B. When I was blown along to C, I was going in a negative direction. Now note the miles traversed. Going from A to B I was doing an ordinary thing; I rowed for 3 miles. At B I had thus gone $+3$ miles; but drifting back to C I went 5 miles in the wrong direction, that is, -5 miles. So I went 3 miles -5 miles. At the end I was thus -2 miles away from home. It would appear that negative quantities are often associated with unpleasantness. I was disgusted at being -2 miles from home after all my labour

Apart from all human considerations, negative or minus quantities are the opposite of positive or plus quantities. In the straight line X'OX, if we agree to call the direction from O to X a positive or plus direction, the direction from O to X' will be a negative or minus direction. If we call the spaces miles, X is $+6$ miles from O, that is, 6 miles; and X' is -6 miles from O. These values are written: $OX=6$ miles, $OX'=-6$ miles. Where is the point A? It is 3 miles to the right of O, that is, 3 miles from O measured in a positive direction. Where is the point B? B is 4 miles to the left of O, that is, 4 miles measured in a negative direction from O. B is therefore -4 miles from O.

Subtract 7 from 4. 7 is 4 and 3. Hence subtracting 7 from a number is the same as subtracting 4 and then 3. So that $4-7$ may be written $4-4-3$. But $4-4=0$. Thus:

$$\begin{aligned} 4-7 &= (4-4)-3 \\ &= 0-3 \\ &= -3 \end{aligned}$$

Questions.

(1) What do I mean when I say I have £5?

Answer. You mean that you have five pounds in your pocket.

Should I write $+$£5?

Answer. It is not necessary; unless the minus sign is there to show the number is negative, the number is positive.

(2) What do I mean when I say I have $-$£5?

Answer. You mean that your pockets are empty, but that you owe some one £5.

(3) I walked from Windsor to a village 7 miles distant. Would you say that I walked 7 miles out and -7 miles back?

Answer. No. If you walked 7 miles out and -7 miles back your total walk would measure $7-7$ miles, that is, 0 miles. You walked 14 miles.

Subtraction in Algebra.—We go on to consider subtraction in algebra. We can write $8-3$ in arithmetic. In algebra, if we make a stand for 8 and b for 3, this becomes $a-b$. What is the difference between 8 and 3? There are two answers:

$$8-3=5$$

or

$$3-8=-5$$

So the difference between a and b may be $a-b$ or $b-a$. Let us return to addition. Add 7 to 2 and you get 9; add 7 to -2 and you get $+5$. For $7=5+2$, and $(5+2)-2=5$, since the addition of two negative units to two positive units yields zero. $a-b$ is the difference between a and b, but it is also the sum of $(a)+(-b)$; that is:

$$a+(-b)=a-b$$

so

$$\begin{aligned} 2a+(-3b) &= 2a-3b \\ 4+(-6) &= 4-6=-2 \\ (-4)+(-3) &= -4-3=-7 \\ 5+(-5) &= 5-5=0 \\ 4a+(-3a) &= 4a-3a=a \\ (-2a)+(-6a) &= -2a-6a=-8a \\ (-9a)+5a &= -9a+5a=-4a \end{aligned}$$

Suppose we are told to add $3x-2a$ to $5x+6a$. We write thus: $(3x-2a)+(5x+6a)$. Remember that you cannot add 3 pigs to 4 cats; likewise you cannot add 3 x's and 7 a's. Write the above without any brackets, thus: $3x-2a+5x+6a$. $3x$ cannot be added to $6a$, just as 3 cattle cannot be added to 6 pigs. But $3x$ and $5x$ added together give $8x$. The expression can therefore be written $8x-2a+6a$. But $-2a$ can be added to $6a$. $6a+(-2a)=6a-2a=4a$. So the whole expression is equal to $8x+4a$.

$$\begin{aligned}&(3x-2a)+(5x+6a)\\&=3x-2a+5x+6a\\&=3x+5x-2a+6a\\&=8x+4a\end{aligned}$$

Add $a-c$ to $b-c$.

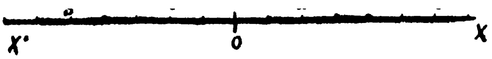
$$\begin{aligned}&(a-c)+(b-c)\\&=a-c+b-c\\&=a+b-c-c\\&=a+b-2c\end{aligned}$$

Subtract $2a$ from $9a$.

$$9a-2a=7a$$

Subtract $2a$ from $9b$.

You can only write the answer in the form $9b-2a$.



When we take 2 from 6 we really ask: What must be added to $+2$ to make $+6$? Look at the X'OX straight line. a is 2 miles to the right of O, that is, $+2$ miles from O; b is $+6$ miles from O. If I am at a and I want to go to b, how many miles do I walk? I walk 4 miles in a positive direction, that is, I walk $+4$ miles.

Now the distance Oa is $+2$ miles
" " Ob is $+6$ "
" " ab is $+4$ "

And $Ob=Oa+ab$
or 6 miles $=$ 2 miles $+4$ miles

Suppose our problem is to take -2 from 6. Otherwise the problem is: What must be added to -2 to make 6, or $-2+$some number $=6$. In our X'OX figure we mark off -2 miles; that is, we find a point 2 miles measured in the direction of OX'. The point is c. And we already know that b is $+6$ miles from O. Now we want to find out how many miles must be added to -2 miles so as to make $+6$ miles. In other words, if I am -2 miles out from O, namely at c, how far do I have to walk to get to the point b, which is 6 miles from O? Obviously 8 miles. In what direction? Towards x, *i.e.* in a positive direction. I therefore walk $+8$ miles.

So $\quad -2+8=6$
or $\quad 6-(-2)=8$

Again, subtract 5 from -2. We say: What do we add to $+5$ to make -2? Mark off $+5$ miles; the point n is $+5$ miles from O, and the point c is -2 miles from O. If I am at n and want to reach c I walk 7 miles in the direction of OX', *i.e.* I walk -7 miles.

Thus $\quad (-5)-2=-7$

Subtract -5 from -2. What do we add to -5 to make -2? The point s is -5 miles from O, the point c is -2 miles from O. What do we add to -5 miles to make -2 miles? Or, how do I get from s to c? I walk 3 miles in the direction of X, that is, $+3$ miles.

So $\quad -5+$some number $=-2$
$\quad -5+3 = -2$

From the above results we have:

$$\begin{aligned}9-4&=5\\4-9&=-5\\9-(-4)&=13\\4-(-9)&=13\\-9-(-4)&=-5\end{aligned}$$

Now we should understand what algebra books mean when they say, "To subtract, change the sign of the lower quantity."

The easy sum

$$\begin{array}{r}24\\13\\\hline 11\end{array}$$

is a subtraction of the positive number 13 from the positive number 24. The plus sign of the lower number is changed into a minus sign, thus:

$$24-13=11$$

So

$$\begin{array}{r}9a\\3a\\\hline 6a\end{array}$$

can be written $9a-3a=6a$.

Apply this to

where -12, a negative quantity, has to be taken from 16, a positive or plus quantity, that is, $+16$. The sign of the lower number must be changed.

Thus $\quad 16-(-12)$
$\quad =16+12=28$

It is evident that to take 3 eggs from a basket of 13 is the same as taking one away, then a second, then a third.

Thus $\quad 13-3=13-1-1-1$
But 3 is $\quad 1+1+1$
So $\quad 13-3=13-(1+1+1)$
$\quad =13-1-1-1$

The minus sign before a bracket changes all the signs following if the brackets are removed. $5-(1+2)$ means that 1 and 2 are to be subtracted from 5. It might therefore be written

$5-1-2$. The brackets have been removed and the minus sign before the bracket has changed the $+2$ into -2. Consider $a+b+(c+d)$. Remove the bracket and there is no change.

$a+b+(c+d)=a+b+c+d$. A plus sign before a bracket does not change any sign when the bracket is removed. But

$$\begin{aligned} a+b-(c+d)&=a+b-c-d \\ 2x+3y-(2x+3y)&=2x+3y-2x-3y \\ &=2x-2x+3y-3y \\ &=0+0 \\ &=0 \end{aligned}$$

$$\begin{aligned} &7-(x+2)+(3-3x)-(7x+2) \\ &=7-x-2+3-3x-7x-2 \\ &=-x-3x-7x+7+3-2-2 \\ &=-11x+10-2-2 \\ &=-11x+8-2 \\ &=6-11x \end{aligned}$$

Subtract $2a-4b+c$ from $4a+2b-3c$. Write thus

$$\begin{aligned} &4a+2b-3c-(2a-4b+c) \\ &=4a+2b-3c-2a+4b-c \\ &=4a-2a+2b+4b-3c-c \\ &=2a+6b-4c. \end{aligned}$$

Subtraction of Decimal Fractions.—Subtracting $\cdot 2$ from $\cdot 5$ is simply subtracting 2 tenths from 5 tenths. The result is 3 tenths, that is, $\cdot 3$. Take $\cdot 9$ apples from 9 apples. This may be written: Take $\frac{9}{10}$ of an apple from 9 apples. Subtract $\frac{9}{10}$ of an apple from 1 apple and you have $\frac{1}{10}$ left. But the other 8 apples are not touched; hence $\frac{9}{10}$ from 9 leave 8 and $\frac{1}{10}$, or $8\frac{1}{10}$ apples, in decimal notation $8\cdot 1$ apples. The sum may be put down thus:

$$\begin{array}{r} 9\cdot 0 \\ \cdot 9 \\ \hline 8\cdot 1 \end{array}$$

In imagination add 10 tenths to top line. Then 9 tenths ($\cdot 9$) from 10 tenths leave 1 tenth ($\cdot 1$). We added 10 tenths to the top line; we must add the same quantity to the lower line in order to preserve the balance. 10 tenths ($\frac{10}{10}$) make 1 unit, 1 unit from 9 units leaves 8 units.

Find the difference between $19\cdot 4$ and $3\cdot 62$. Arrange thus:

$$\begin{array}{r} 19\cdot 40 \\ 3\cdot 62 \\ \hline 15\cdot 78 \end{array}$$

so that units are under units, tenths under tenths, hundredths under hundredths. Begin: 2 hundredths from 0 hundredths you cannot take, but 2 hundredths from 10 hundredths leave 8 hundredths, *i.e.* $\cdot 08$. We added 10 hundredths ($\frac{10}{100}$) to the upper line; we must add the same amount to the lower line. But $\frac{10}{100}$ make a tenth ($\frac{1}{10}$). Add $\frac{1}{10}$ to the $\frac{6}{10}$ of the lower line and you have 7 tenths. 7 tenths from 4 tenths you cannot take, but 7 tenths from 14 tenths leave 7 tenths, or $\cdot 7$. We have added 10 tenths to the top line; add 10 tenths, *i.e.* 1 unit to the bottom line. The 4 units from 19 units give 15 units, or 1 ten 5 units. In practice see that the points are in a vertical line, and then subtract as if the numbers were whole numbers.

Exercises.

(1) Subtract 146 raspberries from a basket containing 1720 strawberries.

Answer. The problem is absurd.

(2) Take 16 shillings from 17 florins.

Answer. We cannot take shillings from anything but shillings. We therefore call the 17 florins 34 shillings.

Then $34s.-16s.=18s.$

(3) John and Peter are friends. John is 12 years of age. What is the difference between their ages?

Answer. We cannot tell, for we do not know Peter's age. When a number is unknown we may call it x. Let Peter then be x years of age. If Peter is the younger, the difference between their ages will be $12-x$ years. If Peter is the elder, the difference will be $x-12$.

(4) What must I add to $\cdot 3$ to make unity?

Answer. $\cdot 3$ is 3 tenths; unity is 10 tenths. I therefore add 7 tenths to 3 tenths, that is, $\cdot 7$ to $\cdot 3$, to make unity ($1\cdot 0$).

(5) What must I add to $\cdot 06$ to make unity?

Answer. $\cdot 06$ is 6 hundredths ($\frac{6}{100}$); unity (or 1) contains 100 hundredths ($\frac{100}{100}$). The difference between $\frac{6}{100}$ and $\frac{100}{100}$ is $\frac{94}{100}$, or in words, 94 hundredths, which may be written $\cdot 94$. Prove by placing numbers thus:

$$\begin{array}{r} \cdot 06 \\ \cdot 94 \\ \hline 1\cdot 00 \end{array}$$

and adding.

Exercises in Addition and Subtraction.—Find the sum of $4a+3b+5c$; $2b+7c+10d$; $a+b+d$. Arrange so that like terms are in a vertical column, thus:

$$\begin{array}{rrrr} 4a+ & 3b+ & 5c & \\ & 2b+ & 7c+ & 10d \\ a+ & b & + & d \\ \hline 5a+ & 6b+ & 12c+ & 11d \end{array}$$

Add $x+y+z$; $2x-3y-4z$; $7x-10y+3z$. Arrange thus:

$$\begin{array}{rrr} x+ & y+ & z \\ 2x- & 3y- & 4z \\ 7x- & 10y+ & 3z \\ \hline 10x- & 12y & \end{array}$$

Adding the first column we have $+3z+z-4z=4z-4z=0$. The second column gives $-10y-3y=-13y$. $-13y+y=-12y$.

It is better to write addition sums in algebra like this:

$$(x+y+z)+(2x-3y-4z)+(7x-10y+3z).$$

Plus before a bracket has no effect on the contents of the bracket, so we may write the sum as:

$$x+y+z+2x-3y-4z+7x-10y+3z.$$

Collect the x's, y's, and z's thus:

$$x+2x+7x+y-3y-10y+z+4z+3z=10x-12y.$$

Subtract $x-a$ from $3x+4a$. We may arrange in two lines, thus:

$$\begin{array}{r} 3x+4a \\ x-\ \ a \\ \hline 2x+5a \\ \hline \end{array}$$

and subtract, remembering that each sign of the lower line is changed during the process. $-a$ becomes $+a$; $+a+4a$ give $+5a$. x becomes $-x$; $-x+3x=+2x$. But it is better to write the sum in this way:

$$(3x+4a)-(x-a).$$

Remove the brackets, and the negative sign changes the $-a$ into $+a$.

$$\begin{aligned} &3x+4a-x+a \\ &=3x-x+4a+a \\ &=2x+5a \end{aligned}$$

Simple brackets like these are easy to deal with, but what are we to make of

$$17x-\{5-[5x-(7+4x)]\}\ ?$$

If we want to simplify this we commence by removing the *inside* brackets, the ones like this ( ). The minus sign before them will change $7+4x$ into $-7-4x$. Well, let us remove the inside brackets:

$$17x-\{5-[5x-7-4x]\}.$$

Now we remove the inside brackets [ ]:

$$17x-\{5-5x+7+4x\}$$

and finally the outer brackets:

$$17x-5+5x-7-4x$$

or $\quad 17x+5x-4x-5-7=18x-12.$

The above work may be shortened by adding like terms at any step of the process.

Simplify $17x+\{4+[5x+(7+4x)]\}$.

Here there are no minus signs to change signs within brackets, so we may remove every bracket and the value of the expression remains the same:

$$17x+4+5x+7+4x=26x+11.$$

Sometimes the inside bracket is denoted by a horizontal line. Thus $3x-\overline{4y+5z}$ is another way of writing $3x-(4y+5z)$.

I have a golf balls. I lose b golf balls; how many golf balls remain to me?

$\quad a$ golf balls $-b$ golf balls remain

or $\quad a-b$ golf balls.

I commence a round of golf with a balls. I lose b balls and then c balls. How many balls remain to me?

After losing b balls I have $a-b$ balls left. But I lose c of these balls, so that finally I have $a-b-c$ balls left. Or solve the problem thus: I lose b balls and then c balls, so that I lose $b+c$ balls in all. Obviously I have $a-(b+c)$ balls left. Removing the brackets I find I have $a-b-c$ balls left.

From x shillings take y pence. We found that we could not take 4 ducks from 10 pigs; so we cannot take y pence from x shillings.

But $\quad$ 1 shilling $=12$ pence
9 shillings $=9\times12$ pence
x shillings $=x\times12$ pence $=12x$ pence
$12x$ pence $-y$ pence $=12x-y$ pence

What do I add to 1 to make x? Think of an easy problem. What do I add to 4 to make 7? I add 3. How do I get the 3? I subtract 4 from 7. So subtract 1 from x. The answer is $x-1$.

What must I subtract from n to make m? Take an easy illustration. What must I subtract from 9 to make 2? I subtract 7. I got the 7 by taking 2 from 9. So I get the answer to the above problem by subtracting m from n. This is written $n-m$.

From twice the sum of a and b take twice their difference.

The sum of a and $b=a+b$.
Twice the sum of a and $b=(a+b)+(a+b)$
$$=2a+2b \quad . \quad . \quad . \quad (1)$$

The difference between a and $b=a-b$.
Twice the difference between a and b
$$\begin{aligned} &=(a-b)+(a-b) \\ &=2a-2b \quad . \quad . \quad . \quad . \quad . \quad (2) \end{aligned}$$

We are told to take (2) from (1).

$$\begin{aligned} &(2a+2b)-(2a-2b) \\ &=2a+2b-2a+2b \\ &=2a-2a+2b+2b \\ &=\qquad 4b \end{aligned}$$

What are the next three integers (*i.e.* whole numbers) above x? Think of a simple instance. What are the next three numbers above 7? They are 8 $(7+1)$, 9 $(7+2)$, 10 $(7+3)$. These numbers are known as CONSECUTIVE NUMBERS (Latin, *consequor*, I follow). The next three numbers above x where x stands for an integer are $x+1$, $x+2$, $x+3$. Beware of saying that the next integer after x is y. If it were, what would be the next integer after z?

What integers intervene between $x-2$ and $x+2$? The next highest integer to 14 is $14+1$ or 15. So the next highest integer to $x-2$ is $x-2+1$ or $x-1$; the next highest after that is $x-1+1$ or x; the next is $x+1$; the next is $x+1+1$ or $x+2$.

The following is the order:

$$x-2;\quad x-1;\quad x;\quad x+1;\quad x+2,$$

so that between $x-2$ and $x+2$ three integers intervene.

If $s=a+b+c$, find the value of $(s-a)+(s-b)-(s-c)$.

Begin by removing the brackets. Then

$$\begin{aligned}(s-a)+(s-b)-(s-c) &= s-a+s-b-s+c\\ &= s+s-s-a-b+c\\ &= 2s-s-a-b+c\\ &= s-a-b+c\end{aligned}$$

But $s=a+b+c$; we therefore substitute $a+b+c$ for s in this expression. Then

$$\begin{aligned}(s-a)+(s-b)-(s-c) &= a+b+c-a-b+c\\ &= a-a+b-b+c+c\\ &= 2c\end{aligned}$$

If $K=(a+b)$ and $L=(a-b)$, find the value of $4K-3L$.

In the expression $4K-3L$ we write $(a+b)$ instead of K, and $(a-b)$ instead of L. So

$$\begin{aligned}4K-3L &= 4\ (a+b)-3\ (a-b)\\ &= (4a+4b)-(3a-3b)\\ &= 4a+4b-3a+3b\\ &= 4a-3a+4b+3b\\ &= a+7b\end{aligned}$$

MULTIPLICATION

Sign of Multiplication is $\times$

Multiplication is a short way of doing addition. When we say that 3 times 2 ducks are 6 ducks, we mean that 2 ducks and 2 ducks and 2 ducks make 6 ducks in all. If we reckon how many eggs are in 9 boxes each containing half a dozen eggs, we may walk along the line of boxes saying: "This one has 6 eggs, this second one has 6 eggs; that's 12 eggs; the third one has 6 eggs; that's 18 eggs," and so on. But we really say 9 sixes make 54. We write this $6\times9=54$. The 6, the number multiplied, is known as the MULTIPLICAND; the 9 is the MULTIPLIER, and the answer 54 is the PRODUCT. Finding the product of 6 and 7 is another way of writing multiplying 6 by 7, or 7 by 6. 4×6 is the same as 6×4. For a squad of 24 men arranged in 4 rows of 6 men is also arranged in 6 rows of 4 men.

Suppose this is the squad:

```
        A
0   0   0   0
0   0   0   0
0   0   0   0        B
0   0   0   0
0   0   0   0
0   0   0   0
```

The captain, A, sees 6 rows of 4 men; the sergeant, B, sees 4 rows of 6 men. Suppose the captain gives the order: "Two front ranks three paces forward—*march*." The new arrangement is this:

```
        A
0   0   0   0
0   0   0   0

0   0   0   0        B
0   0   0   0
0   0   0   0
0   0   0   0
```

The captain, A, now sees 2 rows of 4 men, and 4 rows of 4 men. Thus 2 rows of 4 men +4 rows of 4 men =6 rows of 4 men. That is:

2 fours+4 fours=6 fours

or $2\times4+4\times4=6\times4$.

Hence 3 times 9=3 times (6+3)
=3 times 6+3 times 3

6 times 52=6 times (50+2)
=6 times 50 + 6 times 2

or $6\times52=6\times50+6\times2$

8 times $(a+b)$=8 times a + 8 times b
$=8a+8b$

c times $(a+b)$=c times a + c times b
$=c\times a+c\times b$
$=ca+cb$
$=ac+bc$

The expression ab is confusing. We know that these letters each stand for a number. Suppose a stand for 3, and b for 9. We naturally conclude that ab stands for 39. But it does not; ab is a short way of writing a multiplied by b, or $a\times b$.

So
$$\begin{aligned}xyz &= x\times y\times z\\ 4x &= 4\times x=x\times4\\ ab+bc+cd &= (a\times b)+(b\times c)+(c\times d).\end{aligned}$$

We now reach what are called Prime Factors. The number 6 is 2 times 3, or 2×3; 2 and 3 are called prime factors of 6.

27 is 3 nines; write thus, $27=3\times9$. But 9 is simply 3×3. Hence $27=3\times9$
$=3\times3\times3$

What are the factors of 16?

$$\begin{aligned}16 &= 4 \text{ fours}\\ &= 4\times4\end{aligned}$$

But $4=2\times2$

so $16=4\times4$
$=2\times2\times2\times2$

Find the factors of 12.

$$\begin{aligned}12 &= 4\times3\\ &= 2\times2\times3\end{aligned}$$

Find the factors of 144.

$$\begin{aligned}144 &= 12\times12\\ &= (2\times2\times3)\times(2\times2\times3)\\ &= 2\times2\times2\times2\times3\times3\end{aligned}$$

Since 6 is 3 twos ($6=3\times2$):

6 times 5=3 times 2 fives
$=3\times2$ fives
$=3\times2\times5$

14 times 11=7 times 2 elevens
$=7\times2$ elevens
$=7\times2\times11$

Multiply 72 by 4: 4 times 2 units make 8 units, 4 times 7 tens make 28 tens. Hence the product is 28 tens 8 units, or 288. Consider the following, 172×9.

$$\begin{aligned}172 &= 100+70+2\\ 172\times9 &= (100\times9)+(70\times9)+(2\times9)\\ &= 900+630+18.\end{aligned}$$

In tabular form the process appears thus:

Hundreds.	Tens.	Units.
1	7	2 9
9	63	18

But 18 units are 1 ten and 8 units; 63 tens are 6 hundreds and 3 tens. Hence the usual arrangement:

Hundreds.	Tens.	Units.
1	7	2 9
6 9	1 3	8
15	4	8

or better

Thousands.	Hundreds.	Tens.	Units.
	1	7	2 9
1	5	4	8

Multiply 192 by 10.

$$\begin{array}{r} 192 \\ 10 \\ \hline 1,920 \\ \hline \end{array}$$

10 times 2 units make 20 units, *i.e.* 2 tens 0 units; 10 times 9 tens make 90 tens, which with the 2 tens make 92 tens, or 9 hundreds 2 tens; 10 times 1 hundred make 10 hundreds, which with the 9 hundreds make 19 hundreds. But 10 hundreds make a thousand. Hence the answer is read 1 thousand 9 hundreds, 2 tens, 0 units, or one thousand nine hundred and twenty. Obviously the way to multiply by 10 is to add an 0 to the multiplicand. For example, $71,629 \times 10 = 716,290$. Multiplying by 60 is the same as multiplying by 6 tens, that is, 6×10. Hence to multiply by 60, first multiply by 6 and then add an 0 to the answer.

Multiply 192 by 100.

$$\begin{array}{r} 192 \\ 100 \\ \hline 19,200 \\ \hline \end{array}$$

1 hundred times 2 units = 200 units = 20 tens = 2 hundreds.

1 hundred times 9 tens = 900 tens = 9 thousands.

1 hundred times 1 hundred = 100 hundreds = 10 thousands = 1 ten-thousand.

The answer is therefore 1 ten-thousand, 9 thousands, 2 hundreds, 0 tens, 0 units. The short way to multiply by 100 is to add two noughts to the multiplicand. So multiplying by 1000 is equivalent to adding 3 noughts.

$$9142 \times 700 = 9142 \times 7 \times 100.$$

Hence to multiply by 700, multiply by 7 and add 2 noughts.

Consider now the process of finding the product of two large numbers, say 9167 and 936.

$$936 = 900 + 30 + 6.$$

$$\begin{array}{rl} 9,167 & \\ 936 & \\ \hline 8,250,300 & = 9167 \times 9 \text{ hundreds} \\ 275,010 & = 9167 \times 3 \text{ tens} \\ 55,002 & = 9167 \times 6 \text{ units} \\ \hline 8,580,312 & = 9167 \times (900+30+6) = 9167 \times 936 \end{array}$$

The order may be as follows:

$$\begin{array}{rl} 9,167 & \\ 936 & \\ \hline 55,002 & = 9167 \times 6 \text{ units} \\ 275,01\cancel{0} & = 9167 \times 3 \text{ tens} \\ 8,250,3\cancel{0}\cancel{0} & = 9167 \times 9 \text{ hundreds} \\ \hline 8,580,312 & = 9167 \times 936 \\ \hline \end{array}$$

The noughts crossed out are in practice omitted. The old-fashioned method of teaching multiplication was this: 6 sevens are 42, put the 2 under multiplier 6. 3 sevens are 21, put the 1 under the multiplier 3. 9 sevens are 63, put the 3 under the multiplier 9. In actual practice we use this mechanical guide, for instance, in

$$\begin{array}{r} 2,016,002 \\ 70,020 \\ \hline 40,320,040 \\ 141,120,14 \\ \hline 141,160,460,040 \\ \hline \end{array}$$

We say 2 twos are 4; place 4 under multiplier 2. So also we say 7 twos are 14; place 4 under multiplier 7.

Multiplication of Decimal Fractions.—Multiply 4 tenths by 2 and you have 8 tenths. This is written $\frac{4}{10} \times 2 = \frac{8}{10}$. But 4 tenths may be written ·4, and 8 tenths ·8. Hence 2 times ·4 equals ·8.

It might thus appear that 5 times ·7 apples equals ·35 apples. Let us see. ·7 is 7 tenths ($\frac{7}{10}$); 5 times 7 tenths make 35 tenths. But 10 tenths of an apple make one whole apple, so that 35 tenths of an apple

= 10 tenths of an apple + 10 tenths of an apple + 10 tenths of an apple + 5 tenths of an apple
= 1 whole apple + 1 whole apple + 1 whole apple + 5 tenths of an apple
= 3 apples + ·5 of an apple
= 3·5 apples.

So 5 times ·7 apples = 3·5 apples.

What do 10 times ·6 apples make? ·6 of an apple is $\frac{6}{10}$ of an apple; 10 times 6 tenths

make 60 tenths of an apple, that is, 6 whole apples. Hence 10 times $\cdot 6 = 6$.

Again, let us consider 10 times ·24. ·24 is 2 tenths plus 4 hundredths, or $\frac{2}{10} + \frac{4}{100}$. Multiply by 10.

$$\begin{aligned} \text{10 times 2 tenths} &= \text{20 tenths} \\ &= \text{28 units} \\ \text{10 times 4 hundredths} &= \text{40 hundredths} \\ &= \text{4 tenths.} \end{aligned}$$

$$\begin{aligned} \text{Hence 10 times } \cdot 24 &= \text{2 units + 4 tenths} \\ &= 2\tfrac{4}{10} \\ &= 2\cdot 4 \end{aligned}$$

It will be seen that multiplying by 10 makes tens into hundreds, units into tens, tenths into units, hundredths into tenths, and so on. For example, in $172 \times 10 = 1720$, the 2 units of 172 become 2 tens in the product. So in $17\cdot 2 \times 10 = 172$, the 2 tenths (·2) became 2 units in the product. Now we should understand the old rule, "To multiply by 10 shift the point one place to the right; to multiply by 100 shift the point two places to the right; to multiply by 1000 shift it three places to the right, and so on." For it is evident that when 2·64 is multiplied by 10, the 2 units become 2 tens, the 6 tenths become units, the 4 hundredths become tenths; hence the answer is 26·4. The point has been moved one place to the right.

Now let us multiply 74 oranges by ·3. This is the same as multiplying ·3 oranges by 74. Now ·3 oranges may be written 3 tenths of an orange. Multiply 3 tenths of an orange by 74, and you have 222 tenths of oranges. No one thinks of tenths of an orange; 10 tenths make a whole orange. Therefore 222 tenths of an orange

$$\begin{aligned} &= \text{222 oranges divided by 10} \\ &= \tfrac{222}{10} \quad ,, \\ &= 22\tfrac{2}{10} \quad ,, \\ &= 22\cdot 2 \quad ,, \end{aligned}$$

To multiply by ·3 ($\frac{3}{10}$) is to multiply by 3 and to divide by 10. So multiplying by ·03 ($\frac{3}{100}$) will be multiplying by 3 and dividing by 100.

Multiply 4·016 by 2. Arrange so that the unit figure (2) of the multiplier is under the unit figure (4) of the multiplicand, thus:

$$\begin{array}{l} 4\cdot 716 \\ \underline{2} \\ \underline{\underline{9\cdot 432}} \end{array}$$

Multiply in the usual way: 2 times ·006 make ·012, carry the ·01; 2 times ·01 are ·02 and the carried ·01 makes ·03; 2 times ·7 make 1·4, carry the 1 unit; 2 times 4 units make 8 units and the carried unit makes 9 units. Note that 9·432

$$\begin{aligned} &= \text{9 units + 4 tenths + 3 hundredths} \\ &\qquad \text{+ 2 thousandths} \\ &= 9 + \tfrac{4}{10} + \tfrac{3}{100} + \tfrac{2}{1000} \\ &= 9 + \cdot 4 + \cdot 03 + \cdot 002 \end{aligned}$$

Multiplication in Algebra.—We have seen that a multiplied by b is ab, and $x \times y \times z = xyz$. We must remember that multiplication is simply a form of addition; 7 multiplied by 5 means that 5 rows of 7 flower-pots are added together. So a multiplied by b means that a flower-pots are in a line and that we add up b lines. If $a = 7$ and $b = 5$, then $a \times b = 7 \times 5$

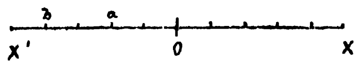
$$\begin{aligned} &= 7+7+7+7+7 \\ &= 35. \end{aligned}$$

Now the sign of a is positive because it has no minus sign in front of it. So also b is positive. We might write $a \times b$ as $(+a) \times (+b)$. The product is ab, or, if you like, $+ab$. Positive terms multiplied together give a positive product:

$$\begin{aligned} (+2a) \times (+2b) &= +4ab \\ a \times b \times c \times d &= abcd. \end{aligned}$$

If we multiply $-a$ by $+4$ we are really adding together $-a$ and $-a$ and $-a$ and $-a$. The sum is obviously $-4a$; thus

$$(-a) \times (+4) \text{ is } -4a.$$

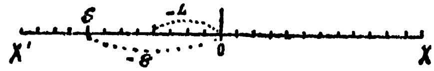


A plus sign multiplied by a minus sign gives a minus sign. This can be seen in the straight line X′OX. We agreed to call spaces measured from O to the right positive or + spaces, and spaces measured to the left of O negative or − spaces. Suppose we have to multiply −2 miles by 2; this is equivalent to adding −2 miles to −2 miles. In the straight line X′OY the line Oa represents 2 miles measured in a negative direction; O$a = -2$ miles. So also ab represents 2 miles measured in a negative direction, that is, another −2 miles. Added together the distances Oa and ab clearly make 4 miles in a negative direction, that is, −4 miles.

$$\begin{array}{ll} \text{Thus} & 2 \text{ times } -2 = -4 \\ \text{So also} & 2 \text{ times } -a = -2a \\ & a \text{ times } -b = +a \times (-b) \\ & \qquad\quad = -ab \end{array}$$

We have discovered that

$$\begin{array}{ll} & \text{plus} \times \text{plus} = \text{plus}, \\ \text{and} & \text{plus} \times \text{minus} = \text{minus}. \end{array}$$



We have yet to consider the case of two negative quantities multiplied together. 4 multiplied by −2 is −8, but what does −4 multiplied by −2 give? Look at the line X′OX. If we had to multiply −4 miles by +2 we should say, "Twice −4 miles make −8 miles." Now if −4 miles multiplied by +2 are −8 miles, −4 miles multiplied by −2 cannot be −8 miles.

If 2 times −4 miles make −8 miles, −2 times

-4 miles will make 8 miles, but *in the opposite direction, i.e.* $+$ 8 miles.

Two minuses multiplied together give a plus. These rules are expressed in the phrase: *Two like signs in multiplication give plus, two unlike signs give minus.*

Examples:

$$+a \times +b = +ab$$

i.e. $$a \times b = ab$$

$$-a \times -b = +ab$$

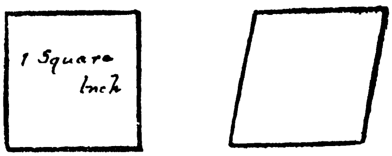
$$-a \times b = -ab$$

$$a \times -b = -ab$$

$$-2x \times -3y = +6xy$$

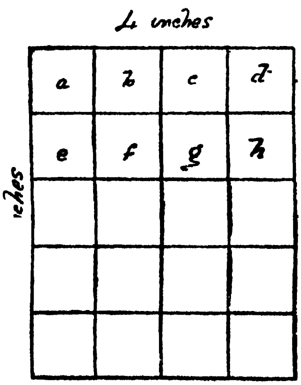
Areas.—Hitherto all our multiplication has been addition: 4 twelves were $12+12+12+12=48$; $4a=a+a+a+a$; $-3a=(-a)+(-a)+(-a)=-a-a-a$; 5 miles $=$ 1 mile $+$ 1 mile $+$ 1 mile $+$ 1 mile $+$ 1 mile.

We measure length by inches, feet, yards, &c. Thus we speak of a rope as being 20 yards long. But when we calculate the area of a table-top we use square measure—square inches, square feet, &c. The first figure is a picture of a square inch.



A child might describe it as a box with four equal sides, each an inch in length.

The definition would not do; the next figure is a box with four equal sides, but it is not a square. If the child said that a square has four equal sides and two sides run straight along (that is, are horizontal), while two sides run straight up and down (that is, are vertical or perpendicular), he would be near a good definition.



This figure is a book cover 4 inches broad and 5 inches long. It is divided into square inches. It will occur to the reader that these square inches look much smaller than the square inch above. We merely *call* these tiny squares square inches: the paper is too small for full-size diagrams. If we are drawing a map we do not use square miles of paper; we agree to call each mile—say—a tenth of an inch.

In our figure a is a square inch, b is a square inch, and so on. a, b, c, and d make up 4 square inches, so do e, f, g, h. We have 5 groups of 4 square inches, or 20 square inches in all. To find this we added the top 4 square inches to the second 4, then to the third 4, and so on. But that is a clumsy method; it is easier to say 5 groups of 4 square inches made 20 square inches.

So a book 4 inches broad and 5 inches long (described generally as being 4 inches by 5 inches) has an area of 20 square inches.

Thus (4×5) square inches $=$ 20 square inches. To find the area of a book, a table-top, a door, &c., multiply the length by the breadth.

Example.—The top of a square table is 4 feet long. What is the area of the top?

The top is square, *i.e.* its sides are each 4 feet in length.

Now area $=$ length $\times$ breadth
$= (4 \times 4)$ square feet
$= 16$ square feet.

Find the area if the top is 6 feet long and 3 feet broad.

Area $=$ length $\times$ breadth
$= (6 \times 3)$ square feet
$= 18$ square feet.

To square a number multiply it by itself. 4 squared $= 16$; 9 squared $= 81$. 4 squared is written 4^2, 9 squared is written 9^2, x squared is written x^2.

Write a^2 in another way.

a^2 is a squared, that is, $a \times a$.

$$ab^2 = a \times (b^2) = a \times b \times b$$

$$a^2b^2c^2 = a \times a \times b \times b \times c \times c$$

If I multiply y by y what do I get? I get y squared (y^2).

If I multiply $-y$ by $-y$, what then? Like signs in multiplication give plus, therefore $-y \times -y = +y^2$.

When we said write a^2 in another way we did not then answer fully.

$a^2 = a$ squared
$= a$ multiplied by itself

Again, $a^2 = -a$ squared
$= -a$ multiplied by itself
$= -a \times -a$.

Hence $a^2 = a \times a$ or $(-a) \times (-a)$.

A plank is 7 inches broad. What is the area of its top surface?

Area of plank $=$ length $\times$ breadth.

But we do not know the length; we cannot then find the answer. Suppose we think of the

symbol x. We know letters in algebra represent numbers. Let us call the length of the planks x inches.

$$\text{Then area} = \text{length} \times \text{breadth}$$
$$= (x \times 7) \text{ square inches}$$
$$= 7x \text{ square inches.}$$

The value of x in this case is not known; x is therefore spoken of as "an unknown quantity."

Exercises in Multiplication.—(1) Is this sentence correct: 4 times 11 ducks are 44? No; it should be: 4 times 11 ducks are 44 ducks.

(2) Express the number 9 as a product.

$9 = 3 \times 3$. The factors of 9 are 3 and 3.

(3) Multiply the tens figure of 96,782 by 4. The tens figure is 8; 4 times 8 tens make 32 tens, *i.e.* 320.

(4) Multiply 742 by 10 and describe the process. Add an 0; the product is 7420.

The 2 units multiplied by 10 become 2 tens				
,,	4 tens	,,	,, ,,	4 hundreds
,,	7 hundreds	,,	,, ,,	7 thousands

The answer is therefore 7 thousands, 4 hundreds, 2 tens, 0 units.

(5) Multiply 39·6 by 10 and explain the process. 10 times 6 tenths are 60 tenths, *i.e.* 6 units; 10 times 9 units make 90 units, *i.e.* 9 tens; 10 times 3 tens make 30 tens, *i.e.* 3 hundreds. The product of $39{\cdot}6 \times 10$ is 396.

(6) Is it true that multiplying by ten involves moving the point one place to the right? Yes. 742 is 7 hundreds, 4 tens, 2 units, 0 tenths, or 742·0. $742{\cdot}0 \times 10 = 7420$. The point has been moved one place to the right.

(7) Is this product right?

```
  24162
    312
  72486 = 24,162  × 3 hundreds
 24162  = 24,162  × 1 ten
  48324 = 24,162  × 2 units
 362430
```

It is wrong. Examine the first partial product, $24{,}162 \times 3$ hundreds. 3 hundred times 2 units make 600 units, *i.e.* 6 hundreds. The 6 therefore should be in the hundreds place under the 1 of the top line. At present it is in the units place. Examine the second partial product, $24{,}162 \times 1$ ten. 2×1 ten give 2 tens. This line is properly placed; the 2 tens are where they should be under the 6 tens of the top line. The third partial product, $24{,}162 \times 2$ units is also in its correct place. For 2×2 units make 4 units. The 4 is rightly placed under the 2 units of the top line.

(8) The prime factors of a number are 2, 3, 5, 7. What is the number? The number is $2 \times 3 \times 5 \times 7$, or 210.

DIVISION

Sign of Division is $\div$

As multiplication is a short way of adding, so division is a short way of subtracting. When 6 apples are divided among Peter, John, and Dick, 2 apples are taken away from the 6 apples and given to Peter. Again, 2 apples are taken from the 4 apples left and given to John. The last 2 apples are handed to Dick. If we write Peter's 2 apples + John's 2 apples + Dick's 2 apples = 6 apples, we see the connection of Division and Addition. The question: How many threes are in 15? simply means: How many threes must be added together to make 15? This question may take the form: How many boys can receive 3 apples each from a basket containing 15? Each boy walks forward and takes away, *i.e.* *subtracts*, 3 apples from the basket. Thus:

Clarence	takes	3 apples
Willie	,,	3 ,,
Fred	,,	3 ,,
Tom	,,	3 ,,
Alexander	,,	3 ,,

The 5 boys take 15 apples in all.

We say 5 threes make 15. Instead of asking: How many threes are in 15? we may ask: What must we multiply 3 by so as to make 15? It is evident that Division, Multiplication, and Subtraction are all forms of Addition. For

$12 \div 3$ (12 divided by 3) means: How many threes *added* together make 12?

12×3 (12 multiplied by 3) means: 12 threes *added* together.

$12 - 3$ (3 subtracted from 12) means: What must be *added* to 3 to make 12?

When 12 is divided by 3 the answer is 4. The 12 is known as the *Dividend*—the number to be *divided*; the 3 is the *Divisor*. The answer 4 is the Quotient (Latin, *quotiens* = how often?). In the time-honoured method of putting down a division sum thus:

```
246 ) 17294 ( 70
      1722
        74
```

the Divisor is 246, the Dividend 17,294, the Quotient 70, and the Remainder 74.

Divisor) Dividend (Quotient

Remainder

Since 20 divided by 4 gives 5, or as it is written, $20 \div 4 = 5$, and 20 is the dividend, 4 the divisor, and 5 the quotient, then

Dividend $\div$ *Divisor* = *Quotient.*

We mentioned the term Remainder. If 4 girls each take 7 sweets from a bag containing

28 sweets, there are no sweets left in the bag. Suppose there are 30 sweets in the bag; the 4 girls each take 7 sweets, and 2 sweets *remain* in the bag. These 2 sweets are known as the Remainder when 30 sweets are divided among 4 girls.

30 sweets = 4 times 7 sweets + a remainder of 2 sweets, that is, Dividend = Divisor × Quotient + Remainder.

The sign of Division is ÷, and a horizontal line between two numbers always suggests division. 9 divided by 3 is written 9÷3, or better, $\frac{9}{3}$. This last is known as "9 over 3," and since the horizontal line implies division, $\frac{9}{3}=9\div3=3$. So a over b $\left(\frac{a}{b}\right)$ means a divided by b, *i.e.* $a\div b$. Earlier in this work we have spoken of tenths; we found that ·1 was $\frac{1}{10}$ of a unit, ·3, $\frac{3}{10}$ of a unit, and so on. We can write 3 tenths $(\frac{3}{10})$ as "3 over 10," or 3 divided by 10 (3÷10).

Let us discover what we really do when we divided 9 by 4.

$$\begin{array}{l} 4\ )\ 9\ (\ 2 \\ \quad\ \ 8 \end{array}$$

We have to find how many times 4 units are contained in 9 units; obviously 2 times. But 2 times 4 units make 8 units only, hence there is a remainder of 1 unit.

We can divide 9 by 4 in this way. $9\div4$ is $\frac{9}{4}$ (9 over 4). Now 1 over 4 $(\frac{1}{4})$ is one-fourth; therefore $\frac{9}{4}$ is 9 fourths. Since there are 4 fourths $(\frac{4}{4})$ in an apple, there are 9 fourths in 2 apples and a fourth of an apple.

So $$\frac{9}{4}=2+\frac{1}{4}$$
$$=2\tfrac{1}{4}.$$

Take the instance of 23 divided by 4.

$$\begin{array}{l} 4\ )\ 23\ (\ 5 \\ \quad\ \ 20 \end{array}$$

We are finding how often 4 units are contained in 23 units, *i.e.* 2 tens + 3 units.

If we write the sum thus:

$$\begin{array}{r|l} 4\ ) & 20+3\ (\ 5 \\ & \underline{20\quad\ \ } \\ & \quad\ \ \underline{+3} \end{array}$$

we ask ourselves how often 4 units are contained in 2 tens, *i.e.* 20.

So 777 divided by 7 may be written:

$$\begin{array}{l} 7\ )\ 777\ (\ 111 \\ \quad\ \underline{7} \\ \quad\ \ 7 \\ \quad\ \underline{7} \\ \quad\quad 7 \\ \quad\quad \underline{7} \\ \quad\quad 0 \end{array} \qquad \text{or} \qquad \begin{array}{l} 7\ )\ 700+70+7\ (\ 100+10+1 \\ \quad\ \underline{700} \\ \quad\quad\quad\ 70 \\ \quad\quad\quad\ \underline{70} \\ \quad\quad\quad\quad\ 7 \\ \quad\quad\quad\quad\ \underline{7} \\ \quad\quad\quad\quad\ 0 \end{array}$$

Divide £923 among 7 men.

$$£923=£900+£20+£3.$$

Out of £900 the 7 men can get £100 each. £700 has thus been distributed among them, and £200+£20+£3 are left. The £200 + the £20 make £220, which divided by 7 will give each man £30 and leave £10 over. Each man has already received £100 and then £30, and £10+£3 or £13 remain to be divided. Each man can receive £1, and there are £6 remaining. The above process may be seen in

$$\begin{array}{l} 7\ )\ 923\ (\ 100+30+1 \\ \quad\ \underline{700} \\ \quad\ \ 223 \\ \quad\ \underline{210} \\ \quad\quad 13 \\ \quad\quad\ \underline{7} \\ \quad\quad\ 6 \end{array}$$

Divide 2162 by 32.

$$\begin{array}{l} 32\ )\ 2162\ (\ 67 \\ \quad\ \ \underline{1920} \\ \quad\quad\ 242 \\ \quad\quad\ \underline{224} \\ \quad\quad\quad 18 \end{array}$$

Note the value of each figure:

3 tens + 2 units) 2 thousands + 1 hundred + 6 tens + 2 units (

Now we never ask how often 3 pears are contained in 12 apples. So we do not ask how often the 3 tens of the divisor are contained in the 2 thousands of the dividend. But we can ask how many times 3 tens are contained in 216 tens. Evidently 70 times. 7 therefore would appear to be the first figure of our answer, or quotient. But our divisor is more than 3 tens; it is 3 tens plus 2 units. 70 times 3 tens + 2 units (32) make 2240. So that 7 as the first figure of the quotient will not do. 70 times 32 are 2240, but we want only 2160. Hence we try 6 as the first figure of the quotient. 60 times 32 = 1920, or 60 times 3 tens + 2 units = 180 tens + 120 units = 180 tens + 12 tens = 192 tens = 1920.

The sum now stands thus:

$$\begin{array}{l} 32\ )\ 2162\ (\ 60 \\ \quad\ \ \underline{1920} \\ \quad\quad\ 242 \end{array}$$

2162÷32 gives a quotient 60 and a remainder of 242. But the remainder can be divided by 32. The remainder 242 is 24 tens + 2 units; the divisor is 3 tens + 2 units. 3 tens are contained in 24 tens 8 times. But 8 times 32 will make 256, which is too large a number. We try 7 times.

Now the sum is:

```
32 ) 2162 ( 60+7
     1920
      242
      224
       18
```

In practice we proceed as follows :

```
982 ) 72164 ( 8
      7856
```

9 into 7 will not go ; 9 into 72 goes 8 times. Place 8 in quotient's place, and multiply 982 by 8. Something is wrong. We cannot subtract 7856 from 7216. 8 is too large a number. We therefore try 7.

```
982 ) 72164 ( 73
      6874
       3424
       2946
        478
```

We then bring down the 4 and say, 9 into 3 will not go ; 9 into 34 goes 3 times. Place 3 in quotient's place. Multiply 982×3. The remainder is 478.

We must thoroughly understand what we mean by the word Remainder. If I divide 5 apples between Peter and John each receives 2 apples, and 1 apple is left. If I divide this apple—the Remainder—between the two boys each receives a half apple. So that an equal division of 5 apples between 2 boys allows $2\frac{1}{2}$ apples to each.

Thus $\quad 5 \div 2 = 2$ and a half

or $\quad \frac{5}{2} = 2\frac{1}{2}$.

Divide 11 pears among 3 boys. Peter, John, and Dick each get 3 pears, and 2 remain. I take a knife and divide one pear into 3 equal parts, *i.e.* into thirds, and I give $\frac{1}{3}$ of a pear to each boy. I do likewise with the other pear, and again each receives $\frac{1}{3}$ of a pear. The division is now :

Peter has 3 pears	+ $\frac{1}{3}$ pear	+ $\frac{1}{3}$ pear	
John	„	„	„
Dick	„	„	„

Each has 3 whole pears and 2-thirds of a pear, or $3\frac{2}{3}$ pears.

So

$$11 \div 3, = 3\tfrac{2}{3} \text{ or } \tfrac{11}{3} = 3\tfrac{2}{3}.$$
$$9 \div 2 = 4\tfrac{1}{2}, \text{ or } \tfrac{9}{2} = 4\tfrac{1}{2}.$$
$$\tfrac{12}{11} = 1\tfrac{1}{11}$$
$$\tfrac{56}{50} = 1\tfrac{6}{50}.$$

Divide £24 equally among 10 men.

```
10 ) £24 ( £2
     20
      4
```

The answer is £2 each, and £4 as remainder. This remainder is to be divided among the 10 men. £4 divided by 10 is £4 over 10, that is, $\frac{4}{10}$ of a pound. Each gets £$\frac{4}{10}$.

Now; 1-tenth of a pound is 2 shillings,

∴ 4-tenths of a pound make 8 shillings.

So $\quad$ £$\frac{24}{10}$ = £$2\frac{4}{10}$

$\quad\quad$ = £2, 8*s*.

Division of Decimal Fractions.—9 apples divided into 3 equal parts give 3 apples. 9 tenths divided into 3 equal parts give 3 tenths. But 9 tenths can be written as ·9. Hence ·9 divided by 3 gives $\frac{3}{10}$, or ·3.

Divide 16·4 by 2.

$16 \div 2 = 8$, $\cdot 4 \div 2 = 4$ tenths $\div 2 = 2$ tenths $= \cdot 2$.

$\therefore 16{\cdot}4 \div 2 = 8{\cdot}2$

$$16{\cdot}4 = 8{\cdot}2.$$

Divide ·216 by 3.

$\cdot 216 = \frac{2}{10} + \frac{1}{100} + \frac{6}{1000}$

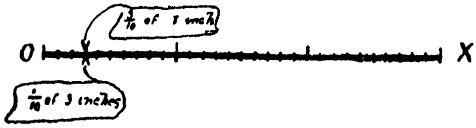
= 2 tenths + 1 hundredth + 6 thousandths

= 21 hundredths + 6 thousandths.

·216 divided by 3 = 21 hundredths + 6 thousandths divided by 3.

$$\frac{\cdot 216}{3} = \frac{21 \text{ hundredths}}{3} + \frac{6 \text{ thousandths}}{3}$$
$$= 7 \text{ hundredths} + 2 \text{ thousandths}$$
$$= \cdot 072.$$

We know that $\frac{1}{3}$ of an orange means that the orange was divided into 3 equal parts, and one of these equal parts was called $\frac{1}{3}$ of an orange. Also that 2 of these equal parts made up 2-thirds of an orange, written $\frac{2}{3}$ of an orange. $\frac{1}{3}$ and $\frac{2}{3}$ are called vulgar fractions ; so also are $\frac{5}{7}$, $\frac{9}{10}$, $\frac{15}{17}$, $\frac{23}{47}$, and so on. And we found that the horizontal line between two numbers means that the top line or Numerator, as it is called, is divided by the bottom line, which is known as the Denominator. Now, since "$\frac{1}{10}$ of an apple" means that one apple is divided into 10 equal parts and one part is taken, "$\frac{3}{10}$ of an apple" means that the apple was divided into 10 equal parts and 3 equal parts were taken. That is, $\frac{3}{10}$ of an apple are 3 tenth parts of an apple. But $\frac{3}{10}$ apples may mean something else. The line between the 3 and the 10 means that 3 apples are *divided by* 10.



OX is a straight line 3 inches long, and each inch is divided into tenths. Think of the first inch only. The cross is 3 tenths of an inch from O ; in other words, the inch is divided into 10 equal parts, and 3 of these parts are measured off. Now think of the whole straight line. It

contains 30 tenths of an inch, and if we divide the whole straight line into 10 equal parts, each part will be 3-tenths of an inch. The distance from O to the cross is thus $\frac{1}{10}$ of the straight line OX. Thus the distance from O to the cross is $\frac{3}{10}$ of one inch and also $\frac{1}{10}$ of 3 inches. So $\frac{3}{10}$ of an inch $=\frac{1}{10}$ of 3 inches.

If we multiply the numerator and the denominator of a fraction each by the same number the value of the fraction is not altered. $\frac{1}{2}$ is a fraction; multiply the 1 by 5 and the 2 by 5 and you have $\frac{5}{10}$, or 5 tenths. But since 10 tenths make one whole, $\frac{5}{10}$ make one half ($\frac{1}{2}$). Multiply the numerator and denominator of $\frac{2}{3}$ by 4 and you have $\frac{8}{12}$. Any penny ruler will show that 2-thirds of an inch are the same as 8-twelfths of an inch. In general then:

$$\frac{6}{7}=\frac{6\times 9}{7\times 9}$$

$$\frac{11}{12}=\frac{11\times 164}{12\times 164}$$

$$\frac{a}{b}=\frac{a\times c}{b\times c}$$

Let us return to our decimals. Suppose we are to divide ·2 by 6. We can write thus: $\cdot 2\div 6=\cdot 2$ over $6=\frac{\cdot 2}{6}$, which is a fraction. Now the value of this fraction is not altered if we multiply the numerator ·2 by a number, and also multiply the denominator 6 by the same number. Suppose we multiply each by 10.

Then $$\frac{\cdot 2}{6}=\frac{\cdot 2\times 10}{6\times 10}=\frac{2}{60}$$

Divide 46 by ·7.

Write thus, $46\div\cdot 7$ is $\frac{46}{\cdot 7}$

We want to get rid of the point, or in better language, we want to make the ·7 a whole number. We can write it ·700,000—as many noughts as we like, since they have no value. Now to multiply by 10 we move the point one place to the right. Thus $\cdot 7000\times 10=7\cdot 000=7$. We find then that

$$\frac{46}{\cdot 7}=\frac{46\times 10}{\cdot 7\times 10}=\frac{460}{7}=65\tfrac{5}{7}$$

The best plan is to make your divisor a whole number. Note that when $\frac{46}{\cdot 7}$ is put down in the form ·7) 46 (, the numerator 46 is called the dividend, the denominator ·7 is called the divisor.

Divide 918 by ·9.

·9) 918 (

We make the divisor ·9 a whole number by multiplying it by 10; we must also multiply the dividend 918 by 10 to preserve the balance. We therefore write the above as:

```
9 ) 9180 ( 1020
    9
    18
    18
     0
```

The quotient is 1020.

Divide 7·42 by ·7. Multiply each by 10, in order to make the divisor a whole number, thus:

```
7 ) 74·2 ( 10·6
    7
     4·2
     4·2

       10·6
or 7 ) 74·2 (
```

The latter method prevents mistakes in fixing the points. Divide 72·164 by 3.

```
     24·054
3 ) 72·164 (
    6
    12
    12
      16
      15
       14
       12
        2
```

How often are 3 units contained in 7 tens? Twice ten times. Place the 2 tens of the quotient over the 7 tens of the dividend and the units will be over the units, tenths over tenths, and so on.

Divide 916·21 by ·046. Make the divisor ·046 a whole number by multiplying it by 1000. Multiply the dividend by 1000 to preserve the balance, and you have 916,210.

$$\frac{916\cdot 21}{\cdot 046}=\frac{916\cdot 210\times 1000}{\cdot 046\times 1000}=\frac{916{,}210}{46}$$

```
      19917·608
46 ) 916,210·000 (
     46
     456
     414
      422
      414
        81
        46
        350
        322
         280
         276
          400
          368
           32
```

Division in Algebra.—15 divided by 3 may be written $15 \div 3$, or $\frac{15}{3}$. So a divided by b is written $\frac{a}{b}$. In arithmetic 25 is $20+5$. So $\frac{25}{5}$ may be written $\frac{20+5}{5}$, or $\frac{20}{5}+\frac{5}{5}$.

Thus $$\frac{25}{5}=\frac{20+5}{5}$$

$$=\frac{20}{5}+\frac{5}{5}$$

or $$5=4+1.$$

The same result may be seen if we divide 18 by 3. Write thus, $\frac{18}{3}$, and call this fraction 18 thirds. Now, 18 thirds are equal to 9 thirds and 9 thirds.

or $$\frac{18}{3}=\frac{9}{3}+\frac{9}{3}.$$

That is, 18 divided by 3 equals 9 divided by 3, plus 9 divided by 3.

So $$\frac{6a}{b}=\frac{3a}{b}+\frac{3a}{b}$$

$$\frac{11c}{d}=\frac{10c}{d}+\frac{c}{d}$$

In multiplication we found that $a \times b = ab$.

$ab \div a$ gives b; $ab \div b$ gives a.

or $$\frac{ab}{a}=b\,;\ \frac{ab}{b}=a.$$

We saw that the value of a fraction is not altered when its numerator and denominator are multiplied by the same number, *e.g.*:

$$\frac{2}{11}=\frac{2\times 9}{11\times 9}=\frac{18}{99}$$

$$\frac{5}{6}=\frac{5\times 100}{6\times 100}=\frac{500}{600}$$

It follows that if the numerator and denominator of a fraction are *divided* by the same number the value of the fraction is unaltered. Take $\frac{500}{600}$, divide numerator and denominator by 100.

Then $$\frac{500}{600}=\frac{500\div 100}{600\div 100}=\frac{5}{6}$$

Consider the fraction $\frac{4}{6}$. The factors of 4 are 2×2; the factors of 6 are 2×3.

So $$\frac{4}{6}=\frac{2\times 2}{2\times 3}$$

Divide numerator and denominator by factor 2 which is common to both.

Then $$\frac{\cancel{2}\times 2}{\cancel{2}\times 3}=\frac{2}{3}$$

Taking away common factors from the two parts of a fraction is what is usually called *Cancelling.* Examples are:

$$\frac{15}{20}=\frac{3\times 5}{4\times 5}$$

5 is a common factor. Cross out the fives, then:

$$\frac{15}{20}=\frac{3\times\cancel{5}}{4\times\cancel{5}}=\frac{3}{4}$$

$$\frac{12}{30}=\frac{\cancel{2}\times 2\times\cancel{3}}{\cancel{2}\times\cancel{3}\times 5}=\frac{2}{5}$$

$$\frac{14}{21}=\frac{2\times\cancel{7}}{3\times\cancel{7}}=\frac{2}{3}$$

$$\frac{17}{170}=\frac{\cancel{17}\times 1}{\cancel{17}\times 10}=\frac{1}{10}$$

$$\frac{ab}{bc}=\frac{a\times b}{b\times c}=\frac{a}{c}$$

$$\frac{b^2}{ab}=\frac{b\times b}{a\times b}=\frac{b}{a}$$

$$\frac{3a^2bc}{24ab^2c}=\frac{\cancel{3}\times a\times a\times b\times c}{\cancel{3}\times 8\times a\times b\times b\times c}=\frac{a}{8\times b}=\frac{a}{8b}$$

Now remember that a vulgar fraction is a division sum. $9ab^2$ divided by $3ab$ might be written:

$$\frac{9ab^2}{3ab}=\frac{\cancel{3}\times 3\times a\times b\times b}{\cancel{3}\times a\times b}=3b$$

or
$$\begin{array}{l} 3ab\ )\ 9ab^2\ (\ 3b \\ \qquad\ \ \underline{9ab^2} \\ \qquad\quad\ 0 \end{array}$$

when we say: What shall we multiply 3 by so as to make 9? a by to make a? b by to make b^2? Obviously $3\times 3=9$, $b\times b=b^2$. But what do we multiply a by to make a? By nothing? $a\times 0$ is $0\times a$, or nothing multiplied by a. And you may multiply 0 by anything you like and you still have 0. So that $a\times 0$ gives 0, not a. But $a\times 1$ will give a, just as 9×1 gives 9. What we actually do in the above division sum is this:

$$\begin{array}{l} 3ab\ )\ 9ab^2\ (\ 3\times 1\times b \\ \qquad\ \ \underline{9ab^2} \end{array}$$

In multiplication we saw that two like signs give plus, two unlike signs give minus.

Like signs	+ multiplied by	+	=	+
	− ,,	−	=	+
Unlike signs	− ,,	+	=	−

In division the same laws hold good.

If $$(+6)\times(+2)=+12$$

then $$\frac{+12}{+6}=+2$$

or $$\frac{+12}{+2}=+6$$

If $-6 \times +2 = -12$

then $\frac{-12}{+2} = -6$

or $\frac{-12}{-6} = +2$

If $-9 \times -3 = +27$

then $\frac{27}{-9} = -3$

or $\frac{27}{-3} = -9.$

Consider

$-3a\ )\ 6ab\ (\ -2b$
$\quad 6ab$

We find our answer by saying: What do we multiply $-3a$ by to make $+6ab$? The quotient must be negative. Again, in

$-7xy\ )\ -14x^2y^2\ (\ 2xy$
$\quad -14x^2y^2$

we say: What do we multiply $-7xy$ by to make $-14x^2y^2$? The quotient must be positive.

Division by Factors.—We know that since $6=2 \times 3$, 2 and 3 are called the factors of 6. We can divide a squad of 18 men into 6 equal parts, but if we divide the squad into 2 equal groups, thus getting 9 men in each group, and the group of 9 men into 3 equal groups, we have the same result—3 men in a group. Thus dividing by 6 is equivalent to dividing by 2, and then dividing the quotient by 3. For example

6) 9324
  1554

6 { 2) 9324
    3) 4662
        1554

In practice we often divide by factors. Instead of dividing by 24 we may divide by 6 and then by 4, since $24=6 \times 4$; or by 8 and then by 3, since $24=3 \times 8$; or by 12 and then by 2, since $24=12 \times 2$. No difficulty arises until there is a remainder. Let us divide 173 by 6:

6) 173
  28 + 5

the quotient is 28 and the remainder 5. If the number 173 referred to hens, the answer means that in 173 hens there are 28 groups of 6 hens, and 5 hens remaining. If 173 simply means 173 units; $\frac{173}{6}=28$ groups of 6 units + 5 units as remainder.

Now divide 173 hens into groups of 2 hens.

2) 173 hens
  86 + 1

We have 86 groups of 2 hens and 1 hen remaining. Divide these 86 groups of 2 hens by 3.

3) 86 groups of 2 hens
  28 + 2

and we have 28 groups of 6 hens + 2 groups of 2 hens remaining.

The full working is:

2) 173 hens
3) 86 groups of 2 hens + 1 hen
  28 „ 6 hens + 2 groups of 2 hens

Add the two remainders. Then 1 hen + 2 groups of 2 hens make 5 hens.

Apply this reasoning to 2131 units divided by 14. The factors of 14 are 2×7. Divide 2131 units by 2.

2) 2131 units
  1065 + 1

and 1065 represents 1065 groups of 2 units. Divide 1065 groups of 2 units by 7.

7) 1065 groups of 2 units
  152 + 1

and 152 represents 152 groups of 14 units + 1 group of 2 units.

2) 2131 units
7) 1065 groups of 2 units + 1 unit
  152 „ 14 „ + 1 group of 2 units.

Divide 17,261 by 77. The factors of 77 are 7×11.

7) 17,261 units
11) 2465 sevens + 6 units
  224 seventy-sevens + 1 seven.

Answer, 224 seventy-sevens + 13 units.

Division by factors leads naturally to reduction of money, weight, &c. For when we ask how many groups of 240 pennies are in 712 pennies, we are dividing 712 pennies by 240. The answer is 2 groups of 240 pennies, *i.e.* 2 pounds, and a remainder of 232 pennies. In daily life we put our pennies into groups of 12 and call each group a shilling; then we put our shillings in groups of 20 and call each group a pound, thus:

12) 712 pence
20) 59 shillings + 4 pence
  2 pounds + 19 shillings.

12×20 are the factors of 240. If we want the remainder of $\frac{712}{240}$ pence to be expressed in pence, we call the 19 shillings 19 groups of 12 pence, and add to these the 4 pence, and we find the remainder to be 19×12 pence + 4 pence, or 232 pence.

Exercises in Multiplication and Division.—We have already learned that $a \times x = ax$, and $a \times a = a^2$ (a squared). a^2 may be spoken of as a raised to the second power. a raised to the third power is a^3 (a cubed) $= a \times a \times a$. So a raised to the fourth power is $a^4 = a \times a \times a \times a$.

$$a^5 = a \times a \times a \times a \times a$$
$$a^7 = a \times a \times a \times a \times a \times a \times a.$$

The numbers 2 of a^2 is called the *index*, and

the plural of this word is *indices*. The indices of a^5 and a^6 are 5 and 6.

Suppose we have to multiply x^2 by x^3.

$$x^2 = x \times x;\quad x^3 = x \times x \times x$$

So that
$$x^2 \times x^3 = (x \times x) \times (x \times x \times x)$$
$$= x \times x \times x \times x \times x = x^5.$$

To multiply one power of a number by another power of the same number we add the indices:

$$x^2 \times x^3 = x^{2+3} = x^5$$
$$a^{10} \times a^{12} \times a^{20} = a^{10+12+20} = a^{42}.$$

It follows that to divide one power of a number by another power of the same number we subtract the indices, *e.g.*:

$$n^5 \div n^3 = \frac{n^5}{n^3}$$
$$= \frac{n \times n \times n \times n \times n}{n \times n \times n}$$

Divide numerator and denominator by $n \times n \times n$.

Then
$$\frac{n \times n \times n \times n \times n}{n \times n \times n} = n \times n = n^2.$$

So that
$$n^5 \div n^3 = n^{5-3} = n^2$$
$$x^7 \div x^2 = x^{7-2} = x^5.$$

Multiply ax^2 by ax. This may be written:

$$ax^2 \times ax$$

or
$$(a \times x \times x) \times (a \times x)$$

or
$$a \times x \times x \times a \times x.$$
$$a \times a = a^2$$
$$x \times x \times x = x^3$$
$$\therefore\quad ax^2 \times ax = a^2x^3.$$

Divide x^4y^5 by xy^3.

$$x^4y^5 \div xy^3 = \frac{x^4y^5}{xy^3}$$
$$= \frac{x \times x \times x \times x \times y \times y \times y \times y \times y}{x \times y \times y \times y}$$
$$= x \times x \times x \times y \times y$$
$$= x^3y^2$$

Find the product of x^3+2x^2-4x+7 and x^2.
Arrange thus:

$$\begin{array}{l} x^3+2x^2-4x+7 \\ \underline{x^2} \\ \underline{x^5+2x^4-4x^3+7x^2} \end{array}$$

Multiply $a-b+2c$ by $2a+b$.
Arrange thus:

$$\begin{array}{lll} & a\ -b+2c & \\ \text{Multiply—} & \underline{2a\ +b} & \\ a-b+2c \text{ by } 2a \text{ thus:} & 2a^2-2ab+4ac & \\ \text{,,}\quad\text{,,}\quad +b\quad\text{,,} & \underline{+\ ab} & \underline{-b^2+2bc} \\ \text{Add} & \underline{2a^2-\ ab+4ac} & \underline{-b^2+2bc} \end{array}$$

Divide $x^2-4x+16$ by $x-7$.
Arrange thus:

$$\begin{array}{l} x-7\ )\ x^2-4x+16\ (\ x \\ x^2-7x \end{array}$$

Divide x^2 of the dividend by x of the divisor and you have x. Multiply $x-7$ by x. As in arithmetic, subtract x^2-7x from x^2-4x, then we have

$$\begin{array}{l} x-7\ )\ x^2-4x+16\ (\ x+3 \\ \underline{x^2-7x} \\ 3x+16 \\ \underline{3x-21} \\ \underline{37} \end{array}$$

Repeat the process: $3x \div x$ gives $+3$; $+3$ times $x-7 = 3x-21$. Again, by subtraction we find a remainder of 37.

Algebraic expressions are usually written in *ascending* powers or *descending* powers. $+x^3+x+x^2$ should be written $+x^3+x^2+x$; $+x+4+x^5+x^2+x^4+x^3$ written in *ascending* powers of x is $4+x+x^2+x^3+x^4+x^5$, in *descending* powers of x it is $+x^5+x^4+x^3+x^2+x+4$. When we are dealing with two letters the powers of the one usually descend, while those of the other ascend, *e.g.* $x^5+x^4a+x^3a^2+x^2a^3+xa^4+a^5$. Note that the powers of x descend, the powers of a ascend.

Divide $6a^3-6ab^2+3b^3-3a^2b$ by b^2+2a^2-3ab. Arrange dividend and divisor in descending powers of a. It will be seen that this arrangement shows ascending powers of b and descending powers of a.

$$\begin{array}{l} 2a^2-3ab+b^2\ )\ 6a^3-3a^2b-6ab^2+3b^3\ (\ 3a+3b \\ \underline{6a^3-9a^2b+3ab^2} \\ 6a^2b-9ab^2+3b^3 \\ \underline{6a^2b-9ab^2+3b^3} \end{array}$$

When expressions are arranged in ascending or descending powers we may perform the operations of multiplication and division by the method of DETACHED COEFFICIENTS. When a number is the product of two factors one factor is called the COEFFICIENT of the other factor. Thus $4a = 4 \times a$. 4 is called the coefficient of a, or the *numerical coefficient*, since it is a number.

The coefficient of $6ax$ is 6, of $7a^2x^2y^3$ is 7, and so on.

Consider the product:

$$\begin{array}{l} 4x^3+2x^2+3x+4 \\ \underline{x^2+4x\ +3} \end{array}$$

The multiplicand $4x^3+2x^2+3x+4$ and the multiplier x^2+4x+3 are arranged in descending powers of x. The product will be found to have a similar arrangement.

$$\begin{array}{rrrrrr} 4x^3+ & 2x^2+ & 3x+ & 4 & & \\ \underline{x^2+} & \underline{4x+} & \underline{3} & & & \\ 4x^5+ & 2x^4+ & 3x^3+ & 4x^2 & & \\ & +16x^4+ & 8x^3+ & 12x^2+ & 16x & \\ & & +12x^3+ & 6x^2+ & 9x+ & 12 \\ \hline 4x^5+ & 18x^4+ & 23x^3+ & 22x^2+ & 25x+ & 12 \end{array}$$

Knowing that the product will be in descending powers of x, we can neglect the symbols altogether and merely write down the coefficients. Note that the coefficient of x^2 is 1, for $x^2 = 1 \times x^2$

$$\begin{array}{l}
4+2+3+4 \\
\underline{1+4+3} \\
4+2+3+4 \\
\quad +16+8+12+16 \\
\qquad\quad +12+6+9+12 \\
\hline
4+18+23+22+25+12
\end{array}$$

The 4 represents $4x^3 \times x^2$, that is, $4x^5$. Hence the product is :

$$4x^5+18x^4+23x^3+22x^2+25x+12.$$

Find the product of x^3+7x+4 and x^2-9. A glance shows the danger of using detached coefficients here, for x^3+7x+4 is not arranged in descending powers of x. The x^2 is wanting. So in x^2-9 the x is wanting. But we can write x^3+7x+4 as x^3+0x^2+7x+4, and x^2-9 as x^2+0x-9, and the descending order is established. Detach the coefficients and you have

$$\begin{array}{l}
1+0+7+4 \\
\underline{1+0-9} \\
1+0+7+4 \\
\qquad -9-0-63-36 \\
\hline
1+0-2+4-63-36
\end{array}$$

The product must begin with $x^3 \times x^2$, *i.e.* x^5. Hence product is $1x^5+0x^4-2x^3+4x^2-63x-36$, that is, $x^5-2x^3+4x^2-63x-36$.

Divide $15a^3-28a^2+33a-14$ by $3a-2$.

Dividend and divisor are arranged in descending powers of a; we may therefore detach the coefficients thus :

$$\begin{array}{l}
3-2\ )\ 15-28+33-14\ (\ 5-6+7 \\
\qquad\quad \underline{15-10} \\
\qquad\qquad -18+33 \\
\qquad\qquad \underline{-18+12} \\
\qquad\qquad\qquad 21-14 \\
\qquad\qquad\qquad \underline{21-14}
\end{array}$$

$15a^3 \div 3a$ gives $5a^2$. The quotient must be arranged in descending powers of a. Hence quotient is $5a^2-6a+7$.

The following products should be committed to memory :

$$\begin{array}{l}
a+b \\
\underline{a+b} \\
a^2+ab \\
\quad\ \underline{+ab+b^2} \\
\underline{a^2+2ab+b^2}
\end{array}$$

a multiplied by a is a^2; $a+b$ multiplied by $a+b$ is $(a+b)^2$.

$(a+b)^2=a^2+2ab+b^2$ . . . . (1)

and $(a-b)^2=a^2-2ab+b^2$ . . . . (2)

Multiply $a+b$ by $a-b$.

$$\begin{array}{l}
a+b \\
\underline{a-b} \\
a^2+ab \\
\quad\ \underline{-ab-b^2} \\
\qquad\quad \underline{-b^2}
\end{array}$$

So $(a+b)\times(a-b)=a^2-b^2$.

Usually this is written

$(a+b)(a-b)=a^2-b^2$. . . (3)

Suppose we are asked to square $2x+3y$. We may multiply $2x+3y$ by $2x+3y$ in the usual way. But when we know that $(a+b)^2=a^2+2ab+b^2$, we can find the value of $(2x+3y)^2$ from this. Call $2x$ a and $3y$ b. Then $(2x+3y)^2$ may be written $(a+b)^2$. But $(a+b)^2=a^2+2ab+b^2$. Now we agreed that a stood for $2x$ and b for $3y$. Let us substitute these values for a and b in

$$(a+b)^2=a^2+2ab+b^2.$$

This becomes

$$\begin{aligned}(2x+3y)^2&=(2x)^2+2(2x)(3y)+(3y)^2\\&=4x^2+12xy+9y^2\end{aligned}$$

Find the value of $(4x+5y)(4x-5y)$. We know that $(a+b)(a-b)=a^2-b^2$.

In the first quantity write a instead of $4x$, and b instead of $5y$. Then

$$(4x+5y)(4x-5y)=(a+b)(a-b)=a^2-b^2.$$

Consider a^2-b^2. We want to have our answer in x and y. We agreed to let a stand for $4x$, and b for $5y$. Substitute these values in a^2-b^2.

$$\begin{aligned}a^2-b^2&=(4x)^2-(5y)^2\\&=16x^2-25y^2\end{aligned}$$

So $(4x+5y)(4x-5y)=16x^2-25y^2$.

Divide x^3+y^3 by $x+y$.

$$\begin{array}{l}
x+y\ )\ x^3+y^3\ (\ x^2-xy+y^2 \\
\qquad\quad \underline{x^3+x^2y} \\
\qquad\qquad -x^2y\qquad +y^3 \\
\qquad\qquad \underline{-x^2y-xy^2} \\
\qquad\qquad\qquad xy^2+y^3
\end{array}$$

Thus $x^3+y^3=(x+y)(x^2-xy+y^2)$.

Also $x^3-y^3=(x-y)(x^2+xy+y^2)$.

These values should be memorised also.

Multiply $a^2+b^2+c^2-ab-bc-ca$ by $a+b+c$. Arrange in descending powers of a.

$$\begin{array}{l}
a^2-ab-ac+b^2-bc+c^2 \\
\underline{a+b+c} \\
a^3-a^2b-a^2c+ab^2-abc+ac^2 \\
\quad +a^2b\qquad -ab^2-abc\qquad +b^3-b^2c+bc^2 \\
\qquad\quad \underline{+a^2c\qquad -abc-ac^2\qquad +b^2c-bc^2+c^3} \\
\qquad\qquad\qquad -3abc\qquad +b^3\qquad\qquad +c^3
\end{array}$$

In later work it will be important to remember that $a^3+b^3+c^3-3abc$

$$\begin{aligned}&=(a^2-ab-ac+b^2-bc+c^2)\times(a+b+c)\\&=(a^2+b^2+c^2-ab-bc-ca)(a+b+c).\end{aligned}$$

The above product may be found in this manner. Call the multiplier $a+(b+c)$, and call the $(b+c)$ K. Then the multiplier is $a+\mathrm{K}$.

$$\begin{array}{l}
a^2+b^2+c^2-ac-bc-ca \\
\underline{a+\mathrm{K}} \\
a^3+ab^2+ac^2-a^2c-abc-ca^2 \\
\qquad\qquad\qquad +a^2\mathrm{K}+b^2\mathrm{K}+c^2\mathrm{K} \\
\qquad\qquad\qquad -ac\mathrm{K}-bc\mathrm{K}-ca\mathrm{K}
\end{array}$$

Rewrite this product, substituting $(a+b)$ for each K.

$$a^3+ab^2+ac^2-a^2c-abc-ca^2+a^2(b+c)+b^2(b+c)$$
$$+c^2(b+c)-ac(b+c)-bc(b+c)-ca(b+c)$$

Remove the brackets

$$a^3+ab^2+ac^2-a^2c-abc-ca^2+a^2b+a^2c+b^3+b^2c$$
$$+bc^2+c^3-abc-ac^2-b^2c-bc^2-abc-ac^2$$
$$=a^3+b^3+c^3-3abc.$$

MONEY

If we want to add 7 pence and 1 halfpenny, we write 7½*d.*, but we could write 7 pence +1 halfpenny, or 14 halfpennies + 1 halfpenny, or 15 halfpennies.

Let us add £1, 4*s.* 6½*d.* + 17*s.* 6¼*d.* + £9, 17*s.* 11½. + £15, 0*s.* 6*d.* Arrange thus:

£	*s.*	*d.*
1	4	6½
	17	6¼
9	17	11½
15	0	6
£25	38	29$\frac{5}{4}$

Adding the farthings we got 5 farthings, the pence 29, and so on. But this answer will not do. 5 farthings = a penny farthing; the penny is added to the pence. 30 pence make 2*s.* 6*d.*; the 2*s.* are carried to the shillings line. The shillings added come to 40*s.*, that is, £2, and the £2 are carried to the pound line. The correct answer is £27, 0*s.* 6¼*d.*

Subtract £19, 16*s.* 4½*d.* from £26, 11*s.* 2½*d.* Arrange thus:

£	*s.*	*d.*
26	11	2½
19	16	4½
£6	14	10

½ from ½ leaves 0. 4*d.* from 2*d.* cannot be taken; add 1*s.* to the 2*d.* making it 14 pence. The 4*d.* from 14*d.* leaves 10*d.* We added 1*s.* to the top line, and to preserve the balance we must add 1*s.* to the lower line. The 16*s.* then becomes 17*s.* 17*s.* from 11*s.* cannot be taken: add 20*s.* to the upper line. The 17*s.* from 31*s.* leave 14*s.* Again, we must add £1 to the lower line to preserve the balance. The £19 thus becomes £20. In practice we work thus: 4*d.* from 2*d.* you can't take, but 4*d.* from 12*d.* leave 8*d.*, 8*d.*+2*d.*=10*d.* 17*s.* from 11*s.* you can't take, but 17*s.* from 20*s.* leave 3*s*, 3*s.*+11*s.*=14*s.*

Multiplication of money is easy.

£	*s.*	*d.*
7	12	6¼
£21	36	18¾

We simply multiply each number of coins by the multiplier. But no one talks of 21 pounds, 36 shillings, and 18 pence 3 halfpennies.

3 halfpennies	= 1½*d.*
18 pence	= 1*s.* 6*d.*
36 shillings	= £1, 16*s.*
21 pounds	= £21

If we have more than 1 halfpenny we divide by 2 to make pennies; if more than 11 pence we divide by 12 to make shillings, and so on.

The actual working of a multiplication sum is as follows:

£	*s.*	*d.*
120	16	7¼
		23
£2779	1	10¾

```
 4 ) 23  farthings
      5  pence + 3 farthings
    161  pence
12 ) 166 pence
      13 shillings + 10 pence
      48
     32
20 ) 381 shillings
      19  pounds + 1 shilling
     360
    240
    2779 pounds
```

In division we divide each number of pounds, shillings, pence, and farthings by the divisor, *e.g.* £16, 8*s.* 8*d.* ÷ 4 = £4, 2*s.* 2*d.* Let us divide £3, 5*s.* 2*d.* by 4. £3 will not divide by 4; we therefore call it 60*s.* and add it to the 5*s.* Then 4 into 65*s.* goes 16 times, and 1*s.* is left as remainder. We call this 1*s.* 12 pence and add it to the 2*d.*, thus getting 14*d.* Then we say 4 in 14 pence, 3 times and 2 pence over. We cannot divide 2 pence by 4, so we call the 2*d.* 8 farthings, which divide by 4.

```
     £  s.  d.
 4 ) 3  5   2 ( 0
    20
 4 ) 65 ( 16
     4
     25
     24
      1
     12
 4 ) 14 ( 3
     12
      2
      4
 4 )  8 ( 2
      8
```

Follow carefully each step in the following :

```
        £    s.  d.
  24 ) 716  12   7½ ( 29 17  2¼
       48
       236
       216
        20
        20
       412
       24
       172
       168
         4
        12
        55
        48
         7
         4
        30
        24
         6
```

Suppose we want to express £6 as so many shillings. We write :

£1 = 20 shillings
∴ £6 = 20 shillings multiplied by 6
= 20 × 6 shillings
= 120 shillings.

Express £5 as so many pence.

£1 = 20 times a shilling
= 20 times 12 pence
= 20 × 12 pence
∴ £5 = 5 times 20 × 12 pence
= 5 × 20 × 12 pence
= 1200 pence.

In practice the above are usually done in this way :

```
 £6               £5
 20               20
 120 shillings    100 shillings
                   12
                 1200 pence
```

Reduce £16, 17s. 4½d. to farthings.

```
  £   s.  d.
 16  17  4½
 20
 337 shillings
 12
 4048 pence
 4
 16194 farthings
```

Observe that when we make £16 into shillings by multiplying by 20 we add in the 17s. So also do we add the 4d. to 337 × 12 pence, and the ½d. (2 farthings) to the 4048 × 4 farthings.

Reduce £10, 10s. 0d. to half-sovereigns.

£1 = 2 half-sovereigns.
£10 = 2 × 10 half-sovereigns.
£10, 10s. = 2 × 10 half-sovereigns plus 1 half-sovereign = 21 half-sovereigns.

```
or   £   s.  d.
    10  10   0
     2
    21 half-sovereigns.
```

Reduce £6, 15s. 0d. to crowns

£1 = 4 crowns
£6 = 4 crowns × 6
= 24 crowns
15s. = 3 crowns
∴ £6, 15s. = 24 crowns + 3 crowns
= 27 crowns.

```
or   £   s.  d.
     6  15   0
     4
    27 crowns
```

Reduce £2, 2s. 6d. to half-crowns.

£1 = 8 half-crowns
£2 = 16 „
2s. 6d. = 1 „
∴ £2, 2s. 6d. = 17 „

```
or   £   s.  d.
     2   2   6
     8
    17 half-crowns
```

Reduce £17, 14s. 6d. to sixpences. Multiply £17 × 20 to make it shillings, and add in the 14s.

```
  £   s.  d.
 17  14   6
 20
 354 shillings
   2
 709 sixpences
```

To make shillings into sixpences we multiply by 2, but we do not add 6 ; we call 6d. one sixpence, and add the one sixpence.

Reduce £12, 12s. 9d. to threepences.

```
  £   s.  d.
 12  12   9
 20
 252 shillings
   4
 1011 threepences
```

There are 4 threepences in a shilling. Note that we add our 9 pence as 3 threepences.

Express £3, 17s. 6d. as fourpences (groats).

```
  £   s.  d.
  3  17   6
 20
 77 shillings
  3
 232½ fourpences
```

£3, 17$s.$ = 77 shillings. In 1 shilling there are 3 groats. In 77 shillings there are 3×77 groats, or 231 groats.

But we have to account for the 6$d.$ We cannot add 6 pence for we are dealing with groats. Sixpence is $4d. + 2d.$ or 1 groat and a half groat, or $1\frac{1}{2}$ groats. We therefore add $1\frac{1}{2}$ groats to our 231 groats, making $232\frac{1}{2}$ groats in all.

Let us now try to express small coins as large coins. Express 1264 shillings as pounds. Every 20 shillings in 1264 shillings go to make a pound; hence we must find how often 20 shillings are contained in 1264 shillings. In other words, we divide 1264 by 20.

$$20\;\underline{)\;1264} \text{ shillings}$$
$$£63 + 4 \text{ shillings}$$

Find the value of 16,240 pence. Every 12 pence in this sum make 1 shilling; divide 16,240 by 12.

$$12\;\underline{)\;16{,}240} \text{ pence}$$
$$1353 + 4 \text{ pence}$$

We might say the value of 16,240 pence is 1353 shillings and 4 pence. But we must express these shillings as pounds.

$$12\;\underline{)\;16{,}240} \text{ pence}$$
$$20\;\underline{)\;\;1353} + 4 \text{ pence}$$
$$67 + 13 \text{ shillings}$$

£67, 13$s.$ 4$d.$ is the value of 16,240 pence. Prove it by reducing £67, 13$s.$ 4$d.$ to pence.

Express 1726 florins as half-sovereigns. A florin is 2$s.$, a half-sovereign is 10$s.$ There are 5 florins in a half-sovereign. How often are 5 florins contained in 1726 florins?

$$5\;\underline{)\;1726} \text{ florins}$$
$$345 + 1 \text{ florin}$$

Thus 1726 florins = 345 half-sovereigns + 1 florin.

How many pounds are in 719 half-crowns? There are 8 half-crowns in a pound; divide 719 half-crowns by 8.

$$8\;\underline{)\;719} \text{ half-crowns}$$
$$89 + 7 \text{ half-crowns}$$

The answer is £89 + 7 half-crowns, or £89, 17$s.$ 6$d.$

The following solution is important:

There are 8 half-crowns in a pound.

$$\therefore \quad 1 \text{ half-crown} = \tfrac{1}{8} \text{ of a pound.}$$
$$\begin{aligned} 719 \text{ half-crowns} &= 719 \text{ eighths of a pound} \\ &= 719 \times \tfrac{1}{8} \text{ of a pound} \\ &= \tfrac{719}{8} \text{ pounds} \\ &= £89\tfrac{7}{8} \\ &= £89,\ 17s.\ 6d. \end{aligned}$$

Express 1264 florins as pounds:

$$\begin{aligned} 1 \text{ florin} &= \tfrac{1}{10} \text{ of a pound} \\ 1264 \text{ florins} &= 1264 \text{ tenths of a pound} \\ &= 1264 \times \tfrac{1}{10} \text{ pounds} \\ &= \tfrac{1264}{10} \text{ pounds} \\ &= £126{\cdot}4 \\ &= £126\tfrac{4}{10} \\ &= £126,\ 8s.\ 0d. \end{aligned}$$

Express 1296 crowns as florins:

$$\begin{aligned} \text{We can write } 1 \text{ crown} &= 2\tfrac{1}{2} \text{ florins} \\ 1296 \text{ crowns} &= 2\tfrac{1}{2} \times 1296 \text{ florins.} \end{aligned}$$

but this method is not satisfactory for beginners.

A child may hold a two-shilling piece in one hand and a five-shilling piece in the other, but he will fail to appreciate their difference in value. Give him 2 separate shillings and 5 separate shillings, and he will at once realise the values of a florin and a crown. So when we change crowns into florins we should change each coin into shillings.

$$\begin{aligned} 1 \text{ crown} &= 5 \text{ shillings} \\ 1296 \text{ crowns} &= 1296 \times 5 \text{ shillings} \\ &= 6480 \text{ shillings.} \end{aligned}$$

We have changed our crowns into shillings. We now proceed to change our shillings into florins. Every 2 shillings will make 1 florin. In 6480 shillings there are $6480 \div 2$ or 3240 florins. The working is done as follows:

$$1296 \text{ crowns}$$
$$\underline{5}$$
$$2\;\underline{)\;6480} \text{ shillings}$$
$$3240 \text{ florins.}$$

Express 1942 shillings as half-crowns. In this case we note that 1 shilling = 2 sixpences and 1 half-crown = 5 sixpences. We therefore change our 1942 shillings into sixpences:

$$\begin{aligned} 1 \text{ shilling} &= 2 \text{ sixpences} \\ 1942 \text{ shillings} &= 2 \times 1942 \text{ sixpences} \\ &= 3884 \text{ sixpences.} \end{aligned}$$

Now every 5 sixpences may be called a half-crown. In 3984 sixpences there are 776 groups of 5 sixpences and 4 sixpences left as remainder.

$$1942 \text{ shillings}$$
$$\underline{2}$$
$$5\;\underline{)\;3884} \text{ sixpences}$$
$$776 + 4 \text{ sixpences.}$$

Answer, 776 half-crowns 4 sixpences, or $776\frac{4}{5}$ half-crowns.

How many guineas are in 21 crowns?

$$\begin{aligned} 1 \text{ crown} &= 5 \text{ shillings} \\ 21 \text{ crowns} &= 5 \times 21 \text{ shillings} \\ &= 105 \text{ shillings.} \end{aligned}$$

Divide 105 shillings by 21 to obtain guineas.

$$105 \text{ shillings} \div 21 = 5 \text{ guineas.}$$

Note that we multiplied 21 crowns by 5 to change them into shillings and then divided our shillings by 21 to make them guineas. This process may be written:

$$(21 \times 5) \div 21 \text{ guineas}$$

or $$\frac{21 \times 5}{21} \text{ guineas}$$

The 21 is a common factor in numerator and denominator, hence we cancel them :

$$\frac{\cancel{21}^{1} \times 5 \text{ guineas}}{\cancel{21}_{1}} = \frac{5}{1} \text{ guineas}$$
$$= 5 \text{ guineas.}$$

How many half-guineas are in 700 half-crowns ?

1 half-crown = 5 sixpences
700 half-crowns = 5 × 700 sixpences
= 3500 sixpences
1 half-guinea = 10*s.* 6*d.* = 21 sixpences.

Find how many piles of 21 sixpences are in 3500 sixpences. 3500 sixpences ÷ 21 = 166 half guineas + 14 sixpences as remainder.

```
      700 half-crowns
        5
  21 ) 3500 sixpences
     166 half-guineas + 14 sixpences.
```

We multiplied 700 half-crowns by 5 and divided the product by 21. This process may be written :

$$\frac{\cancel{700}^{100} \times 5 \text{ half-guineas.}}{\cancel{21}}$$

Cancel 700 and 21 by 7, then answer is :

$$\frac{100 \times 5 \text{ half-guineas}}{3}$$

or $\frac{500 \text{ half-guineas}}{3}$

or $166\frac{2}{3}$ half-guineas.

Weights and Measures.—Reduction of weights and measures is easy if one has mastered reduction of money. If a man is 5 feet 9 inches in height and we are asked to give his height in inches, we say :

1 ft. = 12 in.
5 ft. = 5 × 12 in. = 60 in.
5 ft. 9 in. = 60 in. + 9 in. = 69 in.

So if we want to express 2 yards 2 feet 4 inches as inches, we proceed :

1 yd. = 3 ft.
2 yds. = 6 ft.
2 yds. 2 ft. = 6 ft. + 2 ft. = 8 ft.
1 ft. = 12 in.
8 ft. = 96 in.
8 ft. 4 in. = 96 in. + 4 in. = 100 in.

The usual method is as follows :

```
 yds.  ft.  in.
  2     2    4
  3
  8 ft.
 12
100 in.
```

Express 191642 minutes as weeks, days, &c.

60 minutes make 1 hour. Find how often 60 minutes are contained in 191642 minutes.

```
60 ) 191642 minutes
      3194 hours + 2 minutes.
```

There are 24 hours in a day. Divide 3194 hours by 24.

```
24 ) 3194 hours
      133 days + 2 hours.
```

There are 7 days in a week. Divide 133 days by 7.

```
7 ) 133 days
     19 weeks + 0 days.
```

In practice the working is as follows :

```
      60 ) 191642 minutes
   24 { 6 ) 3194 + 2 minutes
      { 4 ) 532 + 2 }
        7 ) 133 + 0 } + 2 hours
            19+0 days.
```

Answer : 19 weeks, 2 hours, 2 minutes.

Reduce 12 tons 9 cwts. 3 qrs. 17 lbs. to ozs.

```
tons  cwts.  qrs.  lbs.  oz.
 12     9     3     17    0
 20
249 cwts.
  4
999 qrs.
 28
7999
1999
27989 lbs.
   16
167934
27989
447824 oz.
```

Multiply 10 yds. 2 ft. 7 in. by 17.

```
yds.   ft.   in.
 10     2     7
             17
184     1    11
     12 ) 119
            9+11 in.
           34
       3 ) 43
           14+1 ft.
          170
          184 yds.
```

Divide 160 yrs. 171 days 16 hrs. 12 mins. by 19. Ignore leap years.

```
     Yrs.   days  hrs.  mins. Yrs.  days  hrs.  mins.
19 ) 160    171   16    12 (  8     162   17    16
     152
     ---
       8
     365
    ----
    3091
    19
    ---
    119
    114
    ---
      51
      38
      --
      13
      24
      --
      58
     27
     ---
     328
     19
     ---
     138
     133
     ---
       5
      60
     ---
     312
     19
     ---
     122
     114
     ---
       8
```

We do not explain the steps in the above, for they are similar to the steps in multiplication and division of money.

FRACTIONS

We already know that a fraction is a part "broken off." We also know that a vulgar fraction consists of two parts—the numerator and the denominator, called the *terms* of the fraction. When the numerator is less than the denominator, the fraction is a PROPER FRACTION; when greater, the fraction is an IMPROPER FRACTION. $\frac{2}{3}$ is a proper fraction; $\frac{12}{5}$ is an improper fraction. It will be seen that an improper fraction is greater than unity. Two fifths ($\frac{2}{5}$) of an apple are less than a whole apple: six fifths ($\frac{6}{5}$) of an apple are 5 fifths plus 1 fifth of an apple, that is, an apple and a fifth or $1\frac{1}{5}$ apples. Generally when we encounter an improper fraction we divide the numerator by the denominator, thus:

$$\frac{8}{7}=1\frac{1}{7},\ \frac{16}{3}=5\frac{1}{3},\ \frac{120}{9}=13\frac{3}{9}.$$

We discovered that the value of a fraction is not altered when we multiply both numerator and denominator by 2 or 4, or 10 or 649, or a or x, or any number or symbol.

$$\frac{4}{5}=\frac{4\times 2}{5\times 2}$$
$$=\frac{4\times 9}{5\times 9}$$
$$=\frac{4\times x}{5\times x} \text{ and so on.}$$

Now it follows that if we *divide* numerator and denominator by any number the value of the fraction remains unaltered.

For $\frac{9}{12}=\frac{\cancel{3}\times 3}{\cancel{3}\times 4}=\frac{3}{4}$

$\frac{27}{81}=\frac{3\times \cancel{9}}{9\times \cancel{9}}=\frac{3}{9}=\frac{\cancel{3}\times 1}{\cancel{3}\times 3}=\frac{1}{3}$

We already know that this process is called *Cancelling*. In cancelling we often divide numerator and denominator by 2 or 3 or 5, &c., and it is well to know at a glance when a number will divide by 2 &c. without remainder. If the last digit of a number is nought or a multiple of 2, the whole number is divisible by 2. Thus 17294 is divisible by 2, since its last digit 4 is a multiple of 2. 91773 is not divisible by 2; the last digit 3 is not a multiple of 2.

To find whether a number is divisible by 3, add together the digits of the number. Take the number 93645, add the digits $9+3+6+4+5$. The sum is 27, which is a multiple of 3; hence the number 93645 is divisible by 3.

Is 12916 divisible by 3? $1+2+9+1+6=19$. 19 is not a multiple of 3; hence 12916 is not divisible by 3.

A number is divisible by 5 if the last digit is a 5 or a 0. 175, 200, 7160, &c., are divisible by 5.

To cancel by 9, add the digits together; if the sum is divisible by 9 the whole number is divisible by 9. Thus the sum of the digits in 49172 is $4+9+1+7+2$ or 23; 23 is not a multiple of 9, hence 49172 is not divisible by 9. Sum the digits of 711945 and you will find the sum 27 is divisible by 9; therefore 711945 is divisible by 9.

Suppose we want to reduce $\frac{3360}{3528}$ to its lowest terms. 3360 ends in a 0: it therefore cancels by 2. 3528 ends in 8: it also cancels by 2.

$\frac{3360}{3528}=\frac{1680}{1764}$ after cancelling by 2

$=\frac{840}{882}$,, ,, 2 again

$=\frac{420}{441}$,, ,, 2 again.

420 will cancel by 2, but 441 will not. Try 3.

$4+2+0=6$ which divides by 3
$4+4+1=9$,, ,, ,,

Cancel $\frac{420}{441}$ by 3 and it becomes $\frac{140}{147}$.

Try 3 again: $1+4+0=5$, but 5 is not divisible by 3. 140 cancels by 5, but 147 does not. There is no use in trying 6, for $6=3\times 2$, and we found we could not cancel by 3 or 2. Try 7. $\frac{140}{147}$ cancelled by 7 becomes $\frac{20}{21}$ which will reduce no lower. In the case of $\frac{1760}{2170}$ cancel by 10 straight away. In the average case you try 2, then 3, 5, 7, 11, 13, 17, 23.

The student should practise telling at a glance which of two fractions is the greater. It is quite evident that one seventieth ($\frac{1}{70}$) part of a brick is much less than one seventh ($\frac{1}{7}$) of a brick. But if Peter's hat is size $6\frac{7}{8}$ and Bill's is $6\frac{5}{8}$, it is difficult to state whether Peter's head is bigger or smaller than Bill's.

Addition of Vulgar Fractions.—We cannot add 4 ducks to 17 geese; nor can we add 7 tenths to 2 thirds. In dealing with money, when we come to a problem like "add 2 florins to 5 crowns" we say: "2 florins are 4 shillings, 5 crowns are 25 shillings; 4 shillings + 25 shillings = 29 shillings. This is the method we adopt in adding vulgar fractions.

Add $\frac{1}{2}$ to $\frac{1}{10}$. Now we know that $\frac{1}{2}$ is 5 tenths ($\frac{5}{10}$), so we write: $\frac{1}{2}+\frac{1}{10}=\frac{5}{10}+\frac{1}{10}=\frac{6}{10}$.

Add $\frac{1}{3}$ to $\frac{5}{12}$. There are 4 twelfths in a third, so $\frac{1}{3}+\frac{5}{12}=\frac{4}{12}+\frac{5}{12}=\frac{9}{12}=\frac{3}{4}$ (cancelling by 3).

We observe that before one vulgar fraction can be added to another they must have the same denominator.

Add $\frac{1}{3}$ and $\frac{1}{2}$. The common denominator must be a multiple of 3 and also a multiple of 2. Naturally we find the Least Common Multiple of 3 and 2. The multiples of 3 are 3, 6, 9, 12, &c.; the multiples of 2 are 2, 4, 6, 8, &c. 6 is the L.C.M. We rewrite our fractions as sixths.

$$\tfrac{1}{3} \text{ is } \tfrac{2}{6}, \ \tfrac{1}{2} \text{ is } \tfrac{3}{6}: \ \tfrac{2}{6}+\tfrac{3}{6}=\tfrac{5}{6}.$$
$$\therefore \qquad \tfrac{1}{3}+\tfrac{1}{2}=\tfrac{5}{6}.$$

Add $\frac{2}{3}+\frac{5}{6}+\frac{7}{8}+\frac{11}{12}$. The fractions must have a common denominator. Find the Least Common Multiple of 3, 6, 8, and 12. Do it by inspection. The least common multiple of 3 and 6 is 6, of 6 and 8 is 24, of 24 and 12 is 24. Write each fraction as so many twenty-fourths. $\frac{2}{3}=\frac{16}{24}$. Note that we multiply 3 by 8; we must also multiply the numerator 2 by 8 in order to preserve the original value of $\frac{2}{3}$.

So $\frac{5}{6}=\frac{20}{24}$; $\frac{7}{8}=\frac{21}{24}$; $\frac{11}{12}=\frac{22}{24}$.
Hence $\frac{2}{3}+\frac{5}{6}+\frac{7}{8}+\frac{11}{12}=\frac{16}{24}+\frac{20}{24}+\frac{21}{24}+\frac{22}{24}$.

We can add 16 eggs + 20 eggs + 21 eggs + 22 eggs; likewise we can add 16 twenty-fourths + 20 twenty-fourths + 21 twenty-fourths + 22 twenty-fourths, obtaining 79 twenty-fourths—written $\frac{79}{24}$. This is an improper fraction; it is greater than unity, which is $\frac{24}{24}$. Divide numerator by denominator and we have $\frac{79}{24}=3\frac{7}{24}$. The whole process of adding $\frac{2}{3}+\frac{5}{6}+\frac{7}{8}+\frac{11}{12}$ is as follows:

$$\begin{aligned}\tfrac{2}{3}+\tfrac{5}{6}+\tfrac{7}{8}+\tfrac{11}{12}&=\tfrac{16}{24}+\tfrac{20}{24}+\tfrac{21}{24}+\tfrac{22}{24}\\&=\tfrac{79}{24}\\&=3\tfrac{7}{24}.\end{aligned}$$

Add $4\frac{1}{2}+5\frac{5}{6}+2\frac{3}{7}$. In this case we are adding three whole numbers $4+5+2$ and also three vulgar fractions $\frac{1}{2}+\frac{5}{6}+\frac{3}{7}$. To add the fractions find the L.C.M. of 2, 6, and 7. 6 is a multiple of 2; the least common multiple of 6 and 7 is found to be their product, 42. We therefore rewrite each fraction as so many forty-second parts of unity.

$$\begin{aligned}4\tfrac{1}{2}+5\tfrac{5}{6}+2\tfrac{3}{7}&=4+5+2+\tfrac{1}{2}+\tfrac{5}{6}+\tfrac{3}{7}\\&=11+\tfrac{21}{42}+\tfrac{35}{42}+\tfrac{18}{42}\\&=11+\tfrac{74}{42}\\&=11+1\tfrac{32}{42}\\&=12\tfrac{32}{42} \text{ (cancel } \tfrac{32}{42} \text{ by 2)}\\&=12\tfrac{16}{21}.\end{aligned}$$

Subtraction of Vulgar Fractions.—If we subtract 4 books from 7 books we have 3 books remaining. If we subtract 4 tenths from 7 tenths we have 3 tenths remaining.

7 tenths − 4 tenths = 3 tenths

or $\frac{7}{10}-\frac{4}{10}=\frac{3}{10}$.

We cannot find the difference between 9 cows and 5 pigeons. Nor can we at once find the difference between 9 tenths and 3 fifths.

But $\frac{9}{10}-\frac{3}{5}=\frac{9}{10}-\frac{6}{10}=\frac{3}{10}$.

To subtract one vulgar fraction from another we do as we do in addition of fractions—we rewrite the fractions with a common denominator. If I am asked: Which is greater, $\frac{5}{6}$ or $\frac{7}{8}$? I cannot with certainty tell. I find the L.C.M. of 6 and 8 mentally in this way. I say to myself: What are the multiples of 6? They are 12 (but 12 is not a multiple of 8), 18 (but 18 is not a multiple of 8), 24. I have it: 24 is a multiple of 8. 24 is the L.C.M. of 6 and 8. $\frac{5}{6}=\frac{20}{24}$; $\frac{7}{8}=\frac{21}{24}$; hence $\frac{7}{8}$ is the larger.

Now find the value of $\frac{7}{8}-\frac{5}{6}$.

$$\tfrac{7}{8}-\tfrac{5}{6}=\tfrac{21}{24}-\tfrac{20}{24}=\tfrac{1}{24}.$$

Find the difference between $6\frac{7}{8}$ and $2\frac{5}{6}$.

$$\begin{aligned}6\tfrac{7}{8}-2\tfrac{5}{6}&=6\tfrac{21}{24}-2\tfrac{20}{24}\\&=4\tfrac{1}{24}.\end{aligned}$$

The above is simple; we take the whole number 2 from the whole number 6, and the $\frac{20}{24}$ from the $\frac{21}{24}$.

Suppose we are asked to find the difference between $5\frac{1}{2}$ and $1\frac{2}{3}$. Obviously $5\frac{1}{2}$ is the greater, so we must write the expression as $5\frac{1}{2}-1\frac{2}{3}$. The L.C.M. of 2 and 3 is 6. Hence $5\frac{1}{2}-1\frac{2}{3}=5\frac{3}{6}-1\frac{4}{6}$. Now it is easy to subtract the whole number 1 from the whole number 5, but to take $\frac{4}{6}$ from $\frac{3}{6}$ is impossible. A common-sense

method is to think of $5\frac{3}{6}$ as $1+1+1+1+1+\frac{3}{6}$ or $4+1+\frac{3}{6}$; but 1 apple contains $\frac{6}{6}$ of an apple.

$$\therefore \quad 4+1+\tfrac{3}{6}=4+\tfrac{6}{6}+\tfrac{3}{6}=4\tfrac{9}{6}.$$

Thus $5\frac{3}{6}$ is $4\frac{9}{6}$. Now if we rewrite the expression as $4\frac{9}{6}-1\frac{4}{6}$ we see we can take the 1 from the 4 and also the $\frac{4}{6}$ from the $\frac{9}{6}$. The solution is therefore :

$$\begin{aligned}5\tfrac{3}{6}-1\tfrac{4}{6}&=(4+1+\tfrac{3}{6})-1\tfrac{4}{6}\\&=(4+\tfrac{6}{6}+\tfrac{3}{6})-1\tfrac{4}{6}\\&=4\tfrac{9}{6}-1\tfrac{4}{6}\\&=3\tfrac{5}{6}.\end{aligned}$$

In subtracting 17 from 25 we went on the principle that if we add 10 to 25 and 10 to 17 the difference between $25+10$ and $17+10$ is the same as the difference between 25 and 17. Apply this method to $5\frac{1}{2}-1\frac{2}{3}$, or rather $5\frac{3}{6}-1\frac{4}{6}$. Add 1 to $5\frac{3}{6}$ and we have $5\frac{3}{6}+1$ or $5\frac{3}{6}+\frac{6}{6}$ or $5\frac{9}{6}$. Add 1 to $1\frac{2}{3}$ and we have $2\frac{2}{3}$.

$$\begin{aligned}\text{Hence}\qquad 5\tfrac{1}{2}-1\tfrac{2}{3}&=5\tfrac{3}{6}-1\tfrac{4}{6}\\&=(5\tfrac{3}{6}+1)-(1\tfrac{4}{6}+1)\\&=(5\tfrac{3}{6}+\tfrac{6}{6})-(1\tfrac{4}{6}+1)\\&=5\tfrac{9}{6}-2\tfrac{4}{6}\\&=3\tfrac{5}{6}.\end{aligned}$$

A farmer has 100 sheep in a pen. He wants to take out (subtract) 20 sheep in order to show them to another farmer. He enters the pen and he finds that 1 sheep is a frightened animal which rushes about and alarms the others. The farmer becomes annoyed and, seizing the culprit, he pushes it into a neighbouring pen. Then he quietly takes away the 20 sheep he wants. How many sheep are left ? In the pen there are $99-20$ or 79, but if the farmer were asked how many sheep he had left in the pen he would answer "80 sheep," for he would add the 1 sheep in the neighbouring pen.

If I have 7 apples in a basket and I subtract 2 apples, I leave 5 apples behind. Suppose I lay 3 apples *beside* the basket and allow 4 to remain in the basket. I want to subtract 2, so I take 2 from the basket. How many remain ? 5 apples remain, but 3 of them are on the table *beside* the basket. I reason thus : I have $4-2$ in the basket and 3 on the table ; I subtract 2 from the basket. I have 2 apples left *plus* the 3 on the table. Graphically the process is as follows :

$$\begin{aligned}7\text{ apples}&=(4\text{ apples})+(3\text{ apples})\\7\text{ apples}-2\text{ apples}&=(4\text{ apples}-2\text{ apples})\\&\qquad+(3\text{ apples})\\&=2\text{ apples}+3\text{ apples}\\&=5\text{ apples.}\end{aligned}$$

Let us apply this reasoning to $10\frac{1}{3}-4\frac{5}{6}$. Write this as $10\frac{2}{6}-4\frac{5}{6}$. Think of apples. A basket contains $10\frac{2}{6}$ apples, and we have to subtract from it $4\frac{5}{6}$ apples. Take the $\frac{2}{6}$ of an apple out of the basket and place it on the mantelpiece. We have 10 apples in the basket and we are to take away $4\frac{5}{6}$ apples. Now 10 apples are 9 apples + 1 apple, or 9 apples + $\frac{6}{6}$ of an apple.

So $\qquad 10-4\frac{5}{6}=9\frac{6}{6}-4\frac{5}{6}=5\frac{1}{6}.$

We have $5\frac{1}{6}$ apples left in the basket, and we conclude this is the remainder required. But suddenly we recollect the $\frac{2}{6}$ of an apple on the mantelpiece, and we exclaim : "That bit is also left." Our remainder, therefore, is $5\frac{1}{6}$ apples (in the basket) plus $\frac{2}{6}$ apples on the mantelpiece. Remainder $=5\frac{1}{6}+\frac{2}{6}=5\frac{3}{6}=5\frac{1}{2}$. This is the usual method of subtracting.

Find the difference between $11\frac{1}{5}$ and $4\frac{1}{2}$. Rewrite as $11\frac{2}{10}-4\frac{5}{10}$. Take $4\frac{5}{10}$ from 11, which is $10\frac{10}{10}$, and you get $6\frac{5}{10}$; add to this the $\frac{2}{10}$ you ignored and you have $6\frac{7}{10}$.

Addition and subtraction of vulgar fractions are often combined. For example, solve $4\frac{1}{2}-2\frac{1}{3}+1\frac{1}{6}$.

$$\begin{aligned}4\tfrac{1}{2}-2\tfrac{1}{3}+1\tfrac{1}{6}&=4\tfrac{3}{6}-2\tfrac{2}{6}+1\tfrac{1}{6}\\&=4\tfrac{3}{6}+1\tfrac{1}{6}-2\tfrac{2}{6}\\&=5\tfrac{4}{6}-2\tfrac{2}{6}\\&=3\tfrac{2}{6}=3\tfrac{1}{3}.\end{aligned}$$

Solve $3\frac{10}{11}+5\frac{7}{15}-2\frac{9}{22}-4\frac{18}{20}$. Our knowledge of brackets in algebra enables us to rewrite this as :

$$\begin{aligned}&(3\tfrac{10}{11}+5\tfrac{7}{15})-(2\tfrac{9}{22}+4\tfrac{18}{20})\\&=(3\tfrac{150}{165}+5\tfrac{77}{165})-(2\tfrac{90}{220}+4\tfrac{198}{220})\\&=8\tfrac{227}{165}-6\tfrac{288}{220}\\&=8\tfrac{908}{660}-6\tfrac{864}{660}\\&=2\tfrac{44}{660}\text{ (cancel by 11)}\\&=2\tfrac{4}{60}\text{ (cancel by 4)}\\&=2\tfrac{1}{15}.\end{aligned}$$

Multiplication of Vulgar Fractions.—When we multiply 5 ducks by 3 we get 15 ducks. When we multiply 5 tenths ($\frac{5}{10}$) by 3 we get 5×3 tenths or 15 tenths ($\frac{15}{10}$). This is usually expressed as $\frac{5}{10}\times 3=\frac{5\times 3}{10}=\frac{15}{10}$. But when we multiply 5 ducks by 3 we may say 3 times 1 duck make 3 ducks, 5 times 3 ducks make 15 ducks. So we may say 3 times 1 tenth make 3 tenths, and then 5 times $\frac{3}{10}$ make $\frac{5\times 3}{10}$, 15 tenths ($\frac{15}{10}$).

$$\text{Hence}\qquad \frac{5}{10}\times 3=\frac{3}{10}\times 5$$

$$\text{or}\qquad \frac{5\times 3}{10}=\frac{3\times 5}{10}$$

Multiply $\frac{3}{5}$ by 2. 3 fifths $\times 2=3\times 2$ fifths $=\frac{3\times 2}{5}=\frac{6}{5}$.

Multiply $\frac{2}{3}$ by $\frac{3}{4}$. This may be written : Find the value of $\frac{3}{4}$ of $\frac{2}{3}$. The word "of" in arithmetic is equivalent to the sign $\times$.

Now, how do we find $\frac{3}{4}$ of an apple ? We divide the apple into 4 equal parts and select 3 of these parts. So to find $\frac{3}{4}$ of 2 thirds we divide the $\frac{2}{3}$ by 4 and multiply the result by 3. It does not matter whether we divide by 4 and then multiply by 3 or whether we multiply by 3 and then divide by 4.

Multiply $\frac{2}{3}$ by 3. $\frac{2}{3}\times 3=\frac{2\times 3}{3}=\frac{6}{3}$; $\frac{6}{3}\div 4=\frac{6}{3\times 4}=\frac{6}{12}=\frac{1}{2}$.

In multiplication of fractions, therefore, we multiply the numerators together to make a new numerator, and the denominators together to make a new denominator.

$$\text{Thus}\qquad \frac{2}{3}\times\frac{4}{5}=\frac{2\times 4}{3\times 5}=\frac{8}{15}$$

$$=\frac{\overset{1}{\cancel{7}}\times\overset{1}{\cancel{4}}\times\overset{3}{\cancel{15}}}{\underset{2}{\cancel{8}}\times\underset{1}{\cancel{5}}\times\underset{4}{\cancel{28}}}=\frac{3}{8}.$$

In practice we cancel before finding the product: *e.g.* in $\frac{10}{11}\times\frac{22}{25}$ we cancel 10 and 25 by 5 and 22 and 11 by 11.

$$\frac{\overset{2}{\cancel{10}}}{\underset{1}{\cancel{11}}}\times\frac{\overset{2}{\cancel{22}}}{\underset{5}{\cancel{25}}}=\frac{4}{5}$$

Division of Vulgar Fractions.—In dividing 18 by 3 we can write 18 over 3 ($\frac{18}{3}$) is equal to 6. In dividing $\frac{2}{3}$ by 4 we can write 2 thirds $\div$ 4 $=\frac{2}{4}$ thirds $=\frac{2}{4}$ of a third $=\frac{2}{4}\times\frac{1}{3}$. Now 2 fourths of 1 third is equivalent to 1 fourth of 2 thirds. Thus $\frac{2}{4}$ of $\frac{1}{3}=\frac{1}{4}$ of $\frac{2}{3}=\frac{1}{4}\times\frac{2}{3}=\frac{2}{3}\times\frac{1}{4}$. So dividing $\frac{2}{3}$ by 4 is the same as multiplying $\frac{2}{3}$ by $\frac{1}{4}$. Similarly $\frac{4}{5}\div 6=\frac{4}{5}\times\frac{1}{6}$.

A common-sense method of dividing $\frac{2}{3}$ by 4 is this: $\frac{2}{3}\div 4$ is 2 thirds divided by 4 units or $\frac{\text{2 thirds}}{\text{4 units}}$. But 4 units = 12 thirds of a unit, hence $\frac{\text{2 thirds}}{\text{4 units}}=\frac{\text{2 thirds}}{\text{12 thirds}}=\frac{2}{12}=\frac{1}{6}$.

The above method can be applied to $\frac{4}{5}\div\frac{2}{3}$, for the expression may be written 4 fifths $\div$ 2 thirds or $\frac{\text{4 fifths}}{\text{2 thirds}}$. The L.C.M. of 5 and 3 is 15, hence write numerator and denominator as fifteenths $\frac{\text{4 fifths}}{\text{2 thirds}}=\frac{\text{12 fifteenths}}{\text{10 fifteenths}}=\frac{12}{10}=\frac{6}{5}=1\frac{1}{5}$. Our fathers thought division of vulgar fractions easy. They were told to invert the divisor (*i.e.* turn it upside down) and change the sign of division into a sign of multiplication.

Hence our fathers when they saw the expression $\frac{4}{5}\div\frac{2}{3}$ rewrote it thus $\frac{4}{5}\div\frac{2}{3}=\frac{\overset{2}{\cancel{4}}}{5}\times\frac{3}{\underset{1}{\cancel{2}}}=\frac{6}{5}=1\frac{1}{5}$.

We do likewise, but we must find out why we do so. Let us take a simple example, $\frac{4}{1}\div\frac{1}{3}$. Division we found to be addition; to divide 4 apples by $\frac{1}{3}$ of an apple is to find how many thirds of an apple are in 4 apples. In 1 apple there are 3 thirds, in 4 apples there are 3×4 thirds or 12 thirds ($\frac{12}{3}$).

So dividing by $\frac{1}{3}$ is equivalent to multiplying by 3. Thus $14\div\frac{1}{3}=14\times 3$; $\frac{4}{5}\div\frac{1}{3}=\frac{4}{5}\times 3$, or if you like $\frac{4}{5}\times\frac{3}{1}$. We begin to see how $\frac{1}{3}$ is inverted. Now let us divide 4 apples by $\frac{2}{3}$ of an apple.

$$\text{4 apples}\div\tfrac{1}{3}\text{ apples}=4\times 3=12.$$

If we divide 4 by $\frac{1}{3}$ we get 12, but if we divide 4 by $\frac{2}{3}$ we have the half of 12 only. So to divide 4 by $\frac{2}{3}$ we find how many thirds are in 4 and then divide by 2.

$$\text{Thus}\qquad 4\div\tfrac{2}{3}=4\times 3\div 2$$
$$=\frac{4\times 3}{2}$$
$$=4\times\tfrac{3}{2}.$$

$\frac{2}{3}$ has become $\frac{3}{2}$, in short $\frac{2}{3}$ has been inverted.

Again in $\frac{5}{6}\div\frac{5}{12}$ we find how many twelfths are in $\frac{5}{6}$. $\frac{5}{6}\div\frac{1}{12}=\frac{5}{6}\times 12$. Then we divide the result by 5.

$$\frac{5}{6}\div\frac{5}{12}=\frac{5}{6}\times 12\div 5$$

$$=\frac{\overset{1}{\cancel{5}}}{\underset{1}{\cancel{6}}}\times\frac{\overset{2}{\cancel{12}}}{\underset{1}{\cancel{5}}}=2.$$

Various Fractions.—Find the value of $\frac{1}{2}-\frac{1}{3}$ of $\frac{1}{4}-\frac{1}{5}$. The "of" stands for the sign $\times$. Rewrite thus $\frac{1}{2}-\frac{1}{3}$ of $\frac{1}{4}-\frac{1}{5}=\frac{1}{2}-\frac{1}{3}\times\frac{1}{4}-\frac{1}{5}$. In any fraction multiplication and division are done before addition and subtraction.

$$\text{Hence}\qquad \tfrac{1}{2}-\tfrac{1}{3}\times\tfrac{1}{4}-\tfrac{1}{5}=\tfrac{1}{2}-(\tfrac{1}{3}\times\tfrac{1}{4})-\tfrac{1}{5}$$
$$=\tfrac{1}{2}-\tfrac{1}{12}-\tfrac{1}{5}$$
$$=\tfrac{30}{60}-\tfrac{5}{60}-\tfrac{12}{60}$$
$$=\tfrac{13}{60}$$

Solve $(4\frac{4}{5}+3\frac{3}{4})\div(4\frac{4}{5}-3\frac{3}{4})$. In this case the brackets show that $4\frac{4}{5}+3\frac{3}{4}$ and $4\frac{4}{5}-3\frac{3}{4}$ are complete expressions and must be solved first.

$$(4\tfrac{4}{5}+3\tfrac{3}{4})\div(4\tfrac{4}{5}-3\tfrac{3}{4})$$
$$=\frac{4\frac{4}{5}+3\frac{3}{4}}{4\frac{4}{5}-3\frac{3}{4}}$$
$$=\frac{4\frac{16}{20}+3\frac{15}{20}}{4\frac{16}{20}-3\frac{15}{20}}$$
$$=\frac{7\frac{31}{20}}{1\frac{1}{20}}$$
$$=\frac{\frac{171}{20}}{\frac{21}{20}}$$
$$=\frac{\text{171 twentieths}}{\text{21 twentieths}}$$
$$=\frac{171}{21}$$
$$=8\tfrac{3}{21}$$
$$=8\tfrac{1}{7}.$$

Simplify $\frac{4}{7}$ of $\frac{5}{8}$ of $\dfrac{3}{\frac{4}{7}+\frac{5}{8}}-\dfrac{1}{1+\dfrac{1}{4-\frac{3}{14}}}$ (L.C.)

We commence by solving the farthest out part $(4-\frac{3}{14})$.

$$\frac{4}{7} \text{ of } \frac{5}{8} \text{ of } \frac{3}{7+\frac{5}{8}}-\frac{1}{1+\frac{1}{4-\frac{3}{14}}}$$

$$=\frac{4}{7}\times\frac{5}{8}\times\frac{3}{\frac{4}{7}+\frac{5}{8}}-\frac{1}{1+\frac{1}{3\frac{11}{14}}}$$

$$=\frac{4}{7}\times\frac{5}{8}\times\frac{3}{\frac{32}{56}+\frac{35}{56}}-\frac{1}{1+(1\div3\frac{11}{14})}$$

$$=\frac{4}{7}\times\frac{5}{8}\times\frac{3}{\frac{67}{56}}-\frac{1}{1+(1\div\frac{53}{14})}$$

$$=\frac{4}{7}\times\frac{5}{8}\times(3\div\tfrac{67}{56})-\frac{1}{1+(1\times\frac{14}{53})}$$

$$=\frac{4}{\cancel{7}_{1}}\times\frac{5}{\cancel{8}_{1}}\times\frac{3}{1}\times\frac{\overset{\overset{1}{\cancel{8}}}{\cancel{56}}}{67}-\frac{1}{1+\frac{14}{53}}$$

$$=\frac{60}{67}-\frac{1}{1\frac{14}{53}}$$

$$=\frac{60}{67}-(1\div1\tfrac{14}{53})$$

$$=\frac{60}{67}-(1\div\tfrac{67}{53})$$

$$=\frac{60}{67}-(1\times\tfrac{53}{67})$$

$$=\frac{60}{67}-\frac{53}{67}$$

$$=\frac{7}{67}$$

Simplify $\dfrac{\frac{4}{7}(\frac{3}{5}-\frac{5}{11})-\frac{5}{11}(\frac{3}{5}-\frac{4}{7})}{\frac{3}{5}(\frac{4}{7}-\frac{5}{11})-\frac{3}{11}(\frac{4}{5}-\frac{5}{7})}$. (L.C. lower, 1913.)

The brackets show that the expressions $\frac{3}{5}-\frac{5}{11}$, $\frac{3}{5}-\frac{4}{7}$, &c., are complete and must be solved first of all. Note that $\frac{4}{7}(\frac{3}{5}-\frac{5}{11})$ means $\frac{4}{7}$ of $(\frac{3}{5}-\frac{5}{11})$.

or $\frac{4}{7}\times(\frac{3}{5}-\frac{5}{11})$.

$$\frac{\frac{4}{7}(\frac{3}{5}-\frac{5}{11})-\frac{5}{11}(\frac{3}{5}-\frac{4}{7})}{\frac{3}{5}(\frac{4}{7}-\frac{5}{11})-\frac{3}{11}(\frac{4}{5}-\frac{5}{7})}$$

$$=\frac{\frac{4}{7}(\frac{33}{55}-\frac{25}{55})-\frac{5}{11}(\frac{21}{35}-\frac{20}{35})}{\frac{3}{5}(\frac{44}{77}-\frac{35}{77})-\frac{3}{11}(\frac{28}{35}-\frac{25}{35})}$$

$$=\frac{\frac{4}{7}\times\frac{8}{55}-\frac{5}{11}\times\frac{1}{35}}{\frac{3}{5}\times\frac{9}{77}-\frac{3}{11}\times\frac{3}{35}}$$

$$=\frac{\frac{32}{385}-\frac{5}{385}}{\frac{27}{385}-\frac{9}{385}}$$

$$=\frac{\frac{27}{385}}{\frac{18}{385}}$$

$$=\frac{27}{385}\div\frac{18}{385}$$

$$=\frac{\overset{3}{\cancel{27}}}{\underset{1}{\cancel{385}}}\times\frac{\overset{1}{\cancel{385}}}{\underset{2}{\cancel{18}}}$$

$$=\frac{3}{2}$$

$$=1\tfrac{1}{2}.$$

Fractions in Algebra.—When we write $\frac{2}{3}$ we mean that a unit is divided into 3 equal parts and 2 of these parts are taken. So when we write $\frac{a}{b}$ we mean that a unit is divided into b equal parts, and a of these parts are taken.

And since $\quad \frac{2}{3}+\frac{4}{3}+\frac{9}{3}=\frac{2+4+9}{3}=\frac{15}{3}$,

so $\quad \frac{a}{b}+\frac{x}{b}+\frac{y}{b}=\frac{a+x+y}{b}$.

Find the value of $\frac{a}{b}+\frac{b}{c}$. We find the L.C.M. of the denominators b and c. 6 times 2 is a multiple of 2, so c times b is a multiple of b. c times $b=b$ times $c=b\times c=bc$. This is the L.C.M. of b and c. Now to make the denominator b into bc we multiply it by c, but we must also multiply the numerator a by c to preserve the balance. Hence $\frac{a}{b}=\frac{ac}{bc}$. Again to make the denominator c into bc we must multiply it by b, and to preserve the balance we must also multiply the numerator b by b.

Hence $\quad \frac{b}{c}=\frac{b\times b}{bc}=\frac{b^2}{bc}$

$$\frac{a}{b}+\frac{b}{c}=\frac{ac}{bc}+\frac{b^2}{bc}$$

$$=\frac{ac+b^2}{bc}$$

Simplify $\frac{2a}{c}+\frac{3a}{c^2}$. The L.C.M. of c and c^2 is c^2, for c^2 is $c\times c$, which is a multiple of c. To make the denominator c into c^2 we multiply it by c, and we must multiply the numerator by c also.

$$\frac{2a}{c}=\frac{2ac}{c^2}$$

Thus $\quad \frac{2a}{c}+\frac{3a}{c^2}=\frac{2ac}{c^2}+\frac{3a}{c^2}$

$$=\frac{2ac+3a}{c^2}$$

a is common to each term in the numerator. We may therefore take it out as a common factor.

Then $\quad \frac{2ac+3a}{c^2}=\frac{a(2c+3)}{c^2}$

Simplify $\frac{a}{2b}-\frac{b}{3c}+\frac{2a}{6c}$.

The L.C.M. of 2, 3, and 6 is 6. The L.C.M. of b, c, and c is bc. Hence L.C.M. of $2b$, $3c$, and $6c$ is $6\,bc$.

$\frac{a}{2b}$ must be multiplied by $\frac{6bc}{2b}$ or $3c$

$\frac{b}{3c}$ $\qquad\qquad\qquad\frac{6bc}{3c}$ or $2b$

$\frac{2a}{6c}$ $\qquad\qquad\qquad\frac{6bc}{6c}$ or b

$$\frac{a}{2b}-\frac{b}{3c}+\frac{2a}{6c}=\frac{3ac}{6bc}-\frac{2b^2}{6bc}+\frac{2ab}{6bc}$$
$$=\frac{3ac-2b^2+2ab}{6bc}$$

Simplify $\frac{a+b}{a}+\frac{a-b}{b}$.

The L.C.M. of a and b is ab.

Hence $$\frac{a+b}{a}+\frac{a-b}{b}=\frac{b(a+b)}{ab}+\frac{a(a-b)}{ab}$$
$$=\frac{b(a+b)+a(a-b)}{ab}$$
$$=\frac{ab+b^2+a^2-ab}{ab}$$
$$=\frac{a^2+b^2}{ab}.$$

Multiplication of fractions in algebra is similar to multiplication of fractions in arithmetic.

As $$\frac{2}{3}\times\frac{3}{4}=\frac{2\times 3}{3\times 4}=\frac{6}{12}$$

so $$\frac{a}{b}\times\frac{c}{d}=\frac{a\times c}{b\times d}=\frac{ac}{bd}.$$

Multiply $\frac{3a}{4b}\times\frac{2b}{6c}\times\frac{3c}{9a}$.

$$\frac{3a}{4b}\times\frac{2b}{6c}\times\frac{3c}{9a}=\frac{\overset{1}{\cancel{3a}}\times\overset{1}{\cancel{2b}}\times\overset{1}{\cancel{3c}}}{\underset{2}{\cancel{4b}}\times\underset{2}{\cancel{6c}}\times\underset{3}{\cancel{9a}}}$$

Note that in cancelling $3a$ and $9a$ each divides by or cancels by $3a$, so $2b$ and $4b$ cancel by $2b$, $3c$ and $6c$ cancel by $3c$.

The same result would be found in this way :

$$\frac{3a}{4b}\times\frac{2b}{6c}\times\frac{3c}{9a}=\frac{3a\times 2b\times 3c}{4b\times 6c\times 9a}$$
$$=\frac{3\times 2\times 3\times a\times b\times c}{4\times 6\times 9\times b\times c\times a}$$
$$=\frac{18abc}{216abc}$$
$$=\frac{18}{216}$$
$$=\frac{2}{24}$$
$$=\frac{1}{12}$$

Division in algebra is similar to division in arithmetic.

As $$\frac{4}{5}\div\frac{2}{5}=\frac{4}{5}\times\frac{5}{2},$$

so $$\frac{a}{y}\div\frac{a}{b}=\frac{a}{y}\times\frac{b}{a}$$

It is in simplifying fractions that the student finds it necessary to know by heart the factors of expressions like $a^2+2ab+b^2$, a^2-b^2, a^3-b^3, &c. The following example necessitates the use of familiar factors.

Simplify $\frac{x^2-y^2}{x}\times\frac{x}{x+y}$

$$\frac{x^2-y^2}{x}\times\frac{x}{x+y}=\frac{(x^2-y^2)\times x}{x\times(x+y)}$$
$$=\frac{x(x^2-y^2)}{x(x+y)}$$
$$=\frac{x(x+y)(x-y)}{x(x+y)}$$

$x(x+y)$ is a common factor, hence we cancel by $x(x+y)$

Then $$\frac{x(x+y)(x-y)}{x(x+y)}=\frac{x-y}{1}=x-y$$

Simplify $\frac{a-b}{a+b}\times\frac{a^2+2ab+b^2}{a^2-2ab+b^2}$

$$\frac{a-b}{a+b}\times\frac{a^2+2ab+b^2}{a^2-2ab+b^2}=\frac{(a-b)(a^2+2ab+b^2)}{(a+b)(a^2-2ab+b^2)}$$
$$=\frac{(a-b)\times(a+b)^2}{(a+b)\times(a-b)^2}$$
$$=\frac{(a-b)(a+b)(a+b)}{(a+b)(a-b)(a-b)}$$

$(a-b)(a+b)$ is a common factor.

$$=\frac{a+b}{a-b}$$

Simplify $\frac{a+b}{a-b}\div\frac{a^3+b^3}{a^2-b^2}$

$$\frac{a+b}{a-b}\div\frac{a^3+b^3}{a^2-b^2}=\frac{a+b}{a-b}\times\frac{a^2-b^2}{a^3+b^3}$$
$$=\frac{(a+b)\times(a^2-b^2)}{(a-b)\times(a^3+b^3)}$$
$$=\frac{(a+b)\times(a+b)(a-b)}{(a-b)\times(a+b)(a^2-ab+b^2)}$$
$$=\frac{(a+b)(a+b)(a-b)}{(a-b)(a+b)(a^2-ab+b^2)}$$

$(a+b)(a-b)$ is a common factor.

$$=\frac{a+b}{a^2-ab+b^2}$$

Simplify $$\frac{1}{2x+3y}+\frac{2}{2x-3y}-\frac{2x+9y}{4x^2-9y^2}$$

(L.C. lower, 1913).

A glance shows that the solution depends on factors.

$$(a+b)(a-b)=a^2-b^2$$

so $$(2x+3y)(2x-3y)=4x^2-9y^2.$$

The L.C.M. of the three denominations is $(2x+3y)(2x-3y)$.

Hence $$\frac{1}{2x+3y}+\frac{2}{2x-3y}-\frac{2x+9y}{4x^2-9y^2}$$

$$=\frac{2x-3y}{(2x+3y)(2x-3y)}+\frac{2(2x+3y)}{(2x+3y)(2x-3y)}-\frac{2x+9y}{(2x+3y)(2x-3y)}$$

$$=\frac{(2x-3y)+2(2x+3y)-(2x+9y)}{(2x+3y)(2x-3y)}$$

$$=\frac{2x-3y+4x+6y-2x-9y}{(2x+3y)(2x-3y)}$$

$$=\frac{4x-6y}{(2x+3y)(2x-3y)}$$

$$=\frac{2(2x-3y)}{(2x+3y)(2x-3y)}=\frac{2}{2x+3y}$$

Simplify $$\frac{\dfrac{x+a}{x-a}-\dfrac{x-a}{x+a}}{\dfrac{x+a}{x-a}+\dfrac{x-a}{x+a}}$$

Numerator

$$\frac{x+a}{x-a}-\frac{x-a}{x+a}=\frac{(x+a)^2-(x-a)^2}{(x-a)(x+a)}$$

$$=\frac{(x+a+x-a)(x+a-x+a)}{(x-a)(x+a)}$$

$$=\frac{2x\times 2a}{(x-a)(x+a)}$$

Denominator

$$\frac{x+a}{x-a}+\frac{x-a}{x+a}=\frac{(x+a)^2+(x-a)^2}{(x-a)(x+a)}$$

$$=\frac{x^2+2ax+a^2+x^2-2ax+a^2}{(x-a)(x+a)}$$

$$=\frac{2x^2+2a^2}{(x-a)(x+a)}$$

$$=\frac{2(x^2+a^2)}{(x-a)(x+a)}$$

Factor

$$=\frac{2x\times 2a}{(x-a)(x+a)}\div\frac{2(x^2+a^2)}{(x-a)(x+a)}$$

$$=\frac{2x\times 2a}{(x-a)(x+a)}\times\frac{(x-a)(x+a)}{2(x^2+a^2)}$$

$$=\frac{2ax}{x^2+a^2}$$

Simplify $$\frac{x^2-xy+y^2}{x^3-3x^2y+3xy^2-y^3} \text{ of } \frac{x^2-y^2}{x^3+y^3}$$

$$\frac{x^2-xy+y^2}{x^3-3x^2y+3xy^2-y^3} \text{ of } \frac{x^2-y^2}{x^3+y^3}$$

$$=\frac{x^2-xy+y^2}{x^3-3x^2y+3xy^2-y^3}\times\frac{x^2-y^2}{x^3+y^3}$$

$$=\frac{x^2-xy+y^2}{(x-y)^3}\times\frac{(x+y)(x-y)}{(x+y)(x^2-xy+y^2)}$$

$$=\frac{(x^2-xy+y^2)(x+y)(x-y)}{(x-y)(x-y)(x-y)(x+y)(x^2-xy+y^2)}$$

$$=\frac{1}{(x-y)(x+y)}$$

$$\frac{1}{x^2-2xy+y^2}$$

Simplify $$\frac{x^3-3x^2y+3xy^2-y^3}{x^3-x^2y-xy^2+y^3}$$

$$\frac{x^3-3x^2y+3xy^2-y^3}{x^3-x^2y-xy^2+y^3}=\frac{(x-y)^3}{x^3+y^3-x^2y-xy^2}$$

$$\frac{(x-y)^3}{(x^3+y^3)-(x^2y+xy^2)}$$

$$=\frac{(x-y)^3}{(x+y)(x^2-xy+y^2)-xy(x+y)}$$

$$=\frac{(x-y)^3}{(x+y)(x^2-xy+y^2-xy)}$$

$$=\frac{(x-y)^3}{(x+y)(x^2-2xy+y^2)}$$

$$=\frac{(x-y)^3}{(x+y)(x-y)^2}$$

$$=\frac{(x-y)(x-y)(x-y)}{(x+y)(x-y)(x-y)}$$

$$=\frac{x-y}{x+y}$$

Cyclical Order.—If a circle is drawn, and if a is placed at the top, b on the left side, and c at the foot, the order of the letters taken in the direction opposite to the direction taken by the hands of a clock is a, b, c, a. This direction is usually spoken of as a "counter-clockwise" direction. When b follows a, c follows b, a follows c in any algebraical expression, the expression is said to be symmetrical and the symbols are said to be in Cyclical Order. For example $(a-b)(b-c)(c-a)$ is an expression in cyclical order; $(a-b)(c-b)(a-c)$ is not in cyclical order. Generally any expression of the above type should be rewritten in such a way as to have its symbols in cyclical order. Suppose we have $(a-b)$. We leave it as it is: the b follows the a as it should do. Suppose we have $(c-b)$. The b should come first; $(c-b)$ $=(-b+c)$ or $-(b-c)$. Consider $\dfrac{ca}{(b-c)(b-a)}$.

A glance shows that $(b-a)$ is not in cyclical order. We proceed to remedy the fault.

$$\frac{ca}{(b-c)(b-a)}=\frac{ca}{(b-c)(-a+b)}$$
$$=\frac{ca}{(-a+b)(b-c)}$$
$$=\frac{ca}{-(a-b)(b-c)}$$
$$=-\frac{ca}{(a-b)(b-c)}$$

Simplify $\dfrac{b-c}{(a-b)(a-c)}+\dfrac{c-a}{(b-c)(b-a)}+\dfrac{a-b}{(c-a)(c-b)}$

Rearrange in cyclical order.

Then $\dfrac{b-c}{(a-b)(a-c)}+\dfrac{c-a}{(b-c)(b-a)}+\dfrac{a-b}{(c-a)(c-b)}$

$$\frac{b-c}{(a-b)(c-a)}\quad\frac{c-a}{(b-c)(a-b)}\quad\frac{a-b}{(c-a)(b-c)}$$

$$=\frac{-(b-c)(b-c)-(c-a)(c-a)-(a-b)(a-b)}{(a-b)(b-c)(c-a)}$$

$$=\frac{-(b-c)^2-(c-a)^2-(a-b)^2}{(a-b)(b-c)(c-a)}$$

$$=\frac{-(b^2-2bc+c^2)-(c^2-2ac+c^2)-(a^2-2ab+b^2)}{(a-b)(b-c)(c-a)}$$

$$=\frac{-b^2+2bc-c^2-c^2+2ac-c^2-a^2+2ab-b^2}{(a-b)(b-c)(c-a)}$$

$$=\frac{2(ab+bc+ca-a^2-b^2-c^2)}{(a-b)(b-c)(c-a)}$$

Problems involving Fractions.—(1) A man sells $\frac{1}{6}$ of his property and then $\frac{1}{8}$. What fraction of his property is left ?

He sells $\frac{1}{6}+\frac{1}{8}$, *i.e.* $\frac{4}{24}+\frac{3}{24}$ or $\frac{7}{24}$ of his property. Now the whole property contains $\frac{24}{24}$. Hence fraction of property left is $\frac{24}{24}-\frac{7}{24}$ or $\frac{17}{24}$.

(2) A boy has 7*s.* 6*d.* He spends $\frac{1}{3}$ and then $\frac{1}{5}$ of his money. What sum is left ?

He spends in all $\frac{1}{3}+\frac{1}{5}$, *i.e.* $\frac{5}{15}+\frac{3}{15}$ or $\frac{8}{15}$ of his money. But the whole sum contains $\frac{15}{15}$; hence he has $\frac{15}{15}-\frac{8}{15}$ or $\frac{7}{15}$ left.

$\frac{7}{15}$ of 7*s.* 6*d.* $=\frac{7}{15}$ of 15 sixpences
$=$ 7 sixpences
$=$ 3*s.* 6*d.*

(3) A farmer has 120 sheep. He sells $\frac{2}{3}$ of them and $\frac{3}{8}$ of the remainder die of disease. How many sheep died ?

He sells $\frac{2}{3}$, $\therefore$ $\frac{1}{3}$ of his sheep remain. But we are told $\frac{3}{8}$ of the remainder die. Hence $\frac{3}{8}$ of $\frac{1}{3}$ die. Now "of" stands for the sign $\times$. $\therefore$ $\frac{3}{8}\times\frac{1}{3}$ die, *i.e.* $\frac{1}{8}$ die. $\frac{1}{8}$ of 120 sheep is 15 sheep. Therefore 15 sheep die.

(4) A lady spends $\frac{2}{7}$ of her money, and finds that $\frac{3}{8}$ of the remainder is 3*s.* 9*d.* How much had she at first ?

She spends $\frac{2}{7}$ of her money; she therefore had as remainder $\frac{7}{7}-\frac{2}{7}$ or $\frac{5}{7}$ of her money. But we are told that $\frac{3}{8}$ of the remainder is 3*s.* 9*d.*

$\therefore$ $\frac{3}{8}$ of $\frac{5}{7}$ of her money $=$ 3*s.* 9*d.*

But $\frac{3}{8}$ of $\frac{5}{7}=\frac{3}{8}\times\frac{5}{7}=\frac{15}{56}$

So that $\frac{15}{56}$ of her money $=45d.$

$\frac{1}{56}$ „ „ $=\frac{45}{15}d.$

$\frac{56}{56}$ „ „ $=\dfrac{\overset{3}{\cancel{45}}\times 56}{\underset{1}{\cancel{15}}}$

$=168d.$
$=14s.$

(5) A man left $\frac{3}{5}$ of his money to John, $\frac{1}{3}$ of the remainder to Alexander, and the rest to Margaret. The difference between the sons' shares was £840. How much did Margaret receive ?

John received $\frac{3}{5}$ of his father's money. $\therefore$ $\frac{2}{5}$ of the total fortune remained. But Alexander received $\frac{1}{3}$ of the remainder or $\frac{1}{3}$ of $\frac{2}{5}$, *i.e.* $\frac{1}{3}\times\frac{2}{5}$ or $\frac{2}{15}$.

So John's share $=\frac{3}{5}$
Alexander's share $=\frac{2}{15}$.

But the difference between the boys' shares is £840, *i.e.* $\frac{3}{5}-\frac{2}{15}=$ £840.

Now $\frac{3}{5}-\frac{2}{15}=\frac{9}{15}-\frac{2}{15}=\frac{7}{15}$.

So $\frac{7}{15}$ of the whole fortune $=$ £840.

$\frac{1}{15}$ „ „ $=\dfrac{£840}{7}=$ £120.

Margaret receives what is left after the boys get their shares. John's $\frac{3}{5}$ and Alexander's $\frac{2}{15}$ made $\frac{11}{15}$, and as there are $\frac{15}{15}$ in the whole fortune, Margaret receives $\frac{4}{15}$. We found that $\frac{1}{15}$ of the fortune was £120. $\therefore$ $\frac{4}{15}=4\times$ £120 $=$ £480.

(6) What fraction of a pound is 15*s.* ?

1 shilling $=\frac{1}{20}$ of a pound
15 shillings $=15\times\frac{1}{20}$ of a pound
$=\frac{15}{20}$ of a pound
$=£\frac{15}{20}$.
$=£\frac{3}{4}$.

(7) Express 4 lbs. as a fraction of a ton.

1 ton $=$ 20 cwts. $=20\times 112$ lbs. $=$ 2240 lbs.

$\therefore$ 1 lb. $=\frac{1}{2240}$ of a ton
4 lbs. $=\frac{4}{2240}$ „ $=\frac{1}{560}$ of a ton.

ROOTS

A *root* of an expression is a quantity which, being multiplied by itself a requisite number of times, produces the given expression.

Thus $a^2=a\times a$, hence a is a root of a^2
$a^5=a\times a\times a\times a\times a$, hence a is a root of a^5.

The operation of finding a root is known as **Evolution**.

A square is always positive, for $a^2=a\times a$ or $a^2=(-a)\times(-a)$. Hence there is no such thing as the square root of $-a^2$. The square root of 4 is written $\sqrt{4}$. The cube root of a^3 is written $\sqrt[3]{a^3}$, the seventh root of 128 is written $\sqrt[7]{128}$. If we meet with an expression like $\sqrt{-a^2}$ we call it an imaginary quantity, for we cannot take the square root of $-a^2$.

Find the square root of each of the following:

$4,\ 16,\ a^2,\ a^4b^6,\ 9a^2x^2,\ a^8b^2c^{12},\ \dfrac{a^{16}b^8}{16}.$

$$4=2\times 2 \text{ or } -2\times -2 \therefore \sqrt{4}=2 \text{ or } -2 \text{ (or } \pm 2)$$
$$16=4\times 4 \text{ or } -4\times -4 \therefore \sqrt{16}=\pm 4$$
$$a^2=a\times a \text{ or } -a\times -a \therefore \sqrt{a^2}=\pm a$$
$$a^4b^6=a^2b^3\times a^2b^3 \text{ or } -a^2b^3\times -a^2b^3$$
$$\therefore \sqrt{a^4b^6}=\pm a^2b^3$$
$$9a^2x^2=3ax\times 3ax \text{ or } -3ax\times -3ax$$
$$\therefore \sqrt{9a^2x^2}=\pm 3ax$$
$$a^8b^2c^{12}=a^4bc^6\times a^4bc^6 \text{ or } -a^4bc^6\times -a^4bc^6$$
$$\therefore \sqrt{a^8b^2c^{12}}=\pm a^4bc^6$$
$$\frac{a^{16}b^8}{16}=\frac{a^8b^4}{4}\times\frac{a^8b^4}{4} \text{ or } -\frac{a^8b^4}{4}\times -\frac{a^8b^4}{4}$$
$$. a^8b^4$$

Remember that $a^4\times a^4$ is equal to a^8, not a^{16}. The factors of a^3 are $a\times a\times a$; and the cube root of a^3 is a. Thus $\sqrt[3]{a^3}=a$. Again $-a^3=-a\times -a\times -a$, hence cube root of $-a^3$ is $-a$ or $\sqrt[3]{-a^3}=-a$.

Observe the following cube roots:

$$64x^6y^3z^{12}=4\times 4\times 4\times x^2\times x^2\times x^2\times y\times y\times y\times z^4\times z^4\times z^4$$
$$\therefore \sqrt[3]{64x^6y^3z^{12}}=4x^2yz^4$$
$$-\frac{27x^{27}}{64y^{63}}=\left(-\frac{3x^9}{4y^{21}}\right)\times\left(-\frac{3x^9}{4y^{21}}\right)\times\left(-\frac{3x^9}{4y^{21}}\right)$$
$$\sqrt[3]{-\frac{27x^{27}}{64y^{63}}}=-\frac{3x^9}{4y^{21}}$$

Square Root by Inspection.—We know that $(a+b)^2=a^2+2ab+b^2$.

Find the square root of $4x^2+12xy+9y^2$.

$$4x^2+12xy+9y^2=(2x)^2+12xy+(3y)^2$$
$$=(2x)^2+2(2x)(3y)+(3y)^2$$

If $2x=a$ and $3y=b$

expression $=a^2+2ab+b^2$

square root $=\sqrt{a^2+2ab+b^2}$
$=a+b$
$=2x+3y.$

Extract the square root of $9x^2-42xy+49y^2$

$$9x^2-42xy+49y^2=(3x)^2-42xy+(7y)^2$$
$$=(3x)^2-2(3x)(7y)+(7y)^2$$
$$\sqrt{9x^2-42xy+49y^2}=3x-7y.$$

Find the square root of $4a^2+b^2+c^2+4ab-4ac-2bc$.

$$\text{Expression}=4a^2+4ab-4ac+b^2-2bc+c^2$$
$$=(2a)^2+4a(b-c)+(b-c)^2$$
$$=(2a)^2+2(2a)(b-c)+(b-c)^2$$
$$=\{2a+(b-c)\}^2$$
$$\therefore \text{square root}=2a+b-c.$$

The square of any digit is less than 10^2 or 100, hence it has either 1 or 2 digits.

A number of 2 digits is more than 10 and less than 100, hence the square of a number of 2 digits is less than 100^2, *i.e.* 10000, *i.e.* it has either 3 or 4 digits. So the square of a number of 3 digits is less than $(1000)^2$ or 1,000,000, hence it has 5 or 6 digits.

To find how many digits are in the square root of—say—714620 we mark the digits off in pairs from right to left, thus 71/46/20; so we mark 91642 thus, 9/16/42. Each of these numbers has 3 digits in its square root. Always mark from right to left.

Find the first figure in the square root of 71642.

$$2\ \sqrt{7,16,42}\ (\ 2$$
$$4$$
$$\overline{3}$$

2 is the first figure or first approximation; 3 is too big for $3^2=9$.

Let us try to find how the second figure of the root is obtained.

$$(a+b)^2=a^2+2ab+b^2$$

or $$\sqrt{a^2+2ab+b^2}=a+b$$

The first term a of the root is the square root of a^2.

$$a^2+2ab+b^2=a^2+b(2a+b).$$

a^2 is $a\times a$; $b(2a+b)$ is $(2a+b)\times b$.

In extracting the square root of $a^2+2ab+b^2$ we arrange thus:

$$a\ \sqrt{a^2+2ab+b^2}\ (\ a$$
$$a^2$$
$$\text{K}\qquad 2ab+b^2$$

Square root of a^2 is a. We know that the next term of the root is $+b$, and we see that K the divisor must be such that multiplied by b it becomes $2ab+b^2$. K must be $2a+b$. Hence working is

$$a\ \sqrt{a^2+2ab+b^2}\ (\ a+b$$
$$a^2$$
$$2ab+b^2$$
$$2a+b\qquad 2ab+b^2$$

We have doubled the first approximation a and added the second term of the root to it in order to make a new divisor, $2a+b$.

Suppose P is a number whose square root we must find. Let a be the first approximation and x the second term of the root, so that

$a+x$ is the root. Then $P=(a+x)^2$ and $\sqrt{P}=a+x$.

$$\begin{aligned} P &= (a+x)^2 \\ &= a^2+2ax+x^2. \quad \text{Transpose } a^2 \\ \text{then} \quad &= 2ax+x^2 \\ &= x(2a+x) \\ \therefore \quad x &= \frac{P-a^2}{2a+x} \end{aligned}$$

If $P=a^2+2ax+x^2$, $P-a^2=a^2+2ax+x^2-a^2=2ax+x^2=x(2a+x)$.

Let us now find the square root of $a^2+2ax+x^2$.

$$\begin{array}{ll} a & \sqrt{a^2+2ax+x^2(P)}\,(\,a+x \\ & \\ & 2ax+x^2(P-a^2) \\ 2a+x & \underline{2ax+x^2} \end{array}$$

The first divisor a is the square root of a^2. The second divisor is such that if multiplied by x it will give $P-a^2$ or $2ax+x^2$, *i.e.* $x(2a+x)$; it is obviously $2a+x$. Thus the second divisor is found by doubling the first divisor and adding to it the next term of the quotient.

Find the square root of 256.

$$\begin{array}{ll} & 10\sqrt{2{,}56}\,(\,10+6=16 \\ & \underline{100} \\ 2(10)+6=20+6 & \underline{156} \\ & \underline{156} \end{array}$$

10 is the first approximation. Double 10 and add the second term of quotient and you have the new divisor.

Extract the square root of $16a^2+40ab+25b^2$.

$$\begin{array}{ll} 4a & \sqrt{16a^2+40ab+25b^2}\,(\,4a+5b \\ & \underline{16a^2} \\ 2(4a)+5b & 40ab+25b^2 \\ i.e.\ 8a+5b & \underline{40ab+25b^2} \end{array}$$

Find the square root of $49a^4-84a^2b+36b^2$.

$$\begin{array}{ll} 7a^2 & \sqrt{49a^4-84a^2b+36b^2}\,(\,7a^2-6b \\ & 49a^4 \\ & -84a^2b+36b^2 \\ 14a^2-6b & \underline{-84a^2b+36b^2} \end{array}$$

Find the square root of $4x^4-12x^3+29x^2-30x+25$.

$$\begin{array}{ll} 2x^2 & \sqrt{4x^4-12x^3+29x^2-30x+25}\,(\,2x^2-3x+5 \\ & 4x^4 \\ & -12x^3+29x^2-30x+25 \\ 4x^2-3x & -12x^3+\ 9x^2 \\ & 20x^2-30x+25 \\ 4x^2-6x+5 & \underline{20x^2-30x+25} \end{array}$$

The second divisor $4x^2-3x$ was obtained by doubling the term of the root already found $(2x^2)$ and adding the new term $(-3x)$ of the root. The third divisor $4x^2-6x+5$ was obtained by doubling the part of the root already found, viz. $2x^2-3x$ and adding the third term $(+5)$ of the root.

Find the square root of 53824.

$$\begin{array}{ll} 200 & \sqrt{5{,}38{,}24}\,(\,200+30+2 \\ & \underline{40000} \\ & 13824 \\ 400+30=430 & \underline{12900} \\ & 924 \\ 400+60+2=462 & \underline{924} \end{array}$$

In practice this sum is worked thus:

$$\begin{array}{ll} 2 & \sqrt{5{,}38{,}24}\,(\,232 \\ & 4 \\ & 138 \\ 43 & 129 \\ & 924 \\ 462 & 924 \end{array}$$

CUBE ROOT

We know that $(a+b)^3=a^3+3a^2b+3ab^2+b^3$; in other words $a+b$ is the cube root of $a^3+3a^2b+3ab^2+b^3$.

$$\begin{array}{ll} a & \sqrt[3]{a^3+3a^2b+3ab^2+b^3}\,(\,a+b \\ & \underline{a^3} \\ 3a^2+3ab+b^2 & 3a^2b+3ab^2+b^3 \\ & 3a^2b+3ab^2+b^3. \end{array}$$

a is the cube root of a^3. Subtract a^3 from the whole expression and the remainder $3a^2b+3ab^2+b^3$ must be the product of the second division and b.

$$\begin{aligned} b \times \text{second divisor} &= 3a^2b+3ab^2+b^3 \\ \therefore \quad \text{second divisor} &= \frac{3a^2b+3ab^2+b^3}{b} \\ &= \frac{b(3a^2+3ab+b^2)}{b} \\ &= 3a^2+3ab+b^2. \end{aligned}$$

The question is: How do we get $3a^2+3ab+b^2$ if we know the first term of the root is a and the second term b^2?

$3a^2=3$ times a squared
$\quad =3$ times 1st term of root squared
$3ab=3$ times $a\times b$
$\quad =3$ times 1st term of root $\times$ 2nd term of root
$b^2=$2nd term of root squared.

Apply this method to

$$\begin{array}{l} 2x\,\sqrt[3]{8x^3+36x^2y+54xy^2+27y^3}\,(\,2x+3y \\ \quad \underline{8x^3} \\ \qquad 36x^2y+54xy^2+27y^3 \\ \qquad \underline{36x^2y+54xy^2+27y^3} \end{array}$$

Let K be the 2nd term of root. $3(2x)^2+3(2x)K+K^2=12x^2+6xK+K^2$. $12x^2$ into $36x^2y$ goes $3y$ times. $\therefore$ K the 2nd term of root is equal to $3y=12x^2+18xy+9y^2$.

Find the cube root of 274625. Following the method adopted in finding the square root, we

mark off the digits in groups of three from right to left.

$$60\ \sqrt[3]{274,625}\ (\ 60+5$$
$$216000$$
$$58625$$
$$58625$$

$$3(60)^2+3(60)K+K^2 = 3(3600)+180K+K^2$$
$$= 10800 \quad +180K+K^2$$
$$= 1800 \quad +900+25 = 11725.$$

FACTORS

If a number (call it x) is contained in another number (call it y) a number of times without any remainder, x is said to be a factor of y. Thus 3 is contained in 15 five times without remainder; 3 is a factor of 15. 7 is contained in 23 three times, but with a remainder of 2. 7, therefore, is *not* a factor of 23. What are the factors of 12? 12 is exactly divisible by 1, 2, 3, 4, 6, and 12. Hence the factors of 12 are 1, 2, 3, 4, 6, 12. What are the factors of 30? 30 will divide, without remainder, by 1, 2, 3, 5, 6, 10, 15, 30; these numbers are the factors of 30. Some numbers have no factors except themselves and 1, *e.g.* the factors of 7 are 1 and 7; the factors of 23 are 1 and 23. Numbers of this kind are called PRIME NUMBERS. Is 18 a prime number? The factors of 18 are 1, 2, 3, 6, 9, 18, hence 18 is not a prime number.

The PRIME FACTORS of a number are those factors which are prime numbers. The factors of 56 are 1, 2, 4, 7, 8, 14, 28, 56. But these factors are not all prime factors. 4 has factors, 1, 2, and 4; 8 has 1, 2, 4, 8; 14 has factors 1, 2, 7, 14, and so on. The only prime factors in the above lot are 1, 2, and 7.

The term Common Factor is much used in mathematics. The word "common" has two distinct meanings. We speak of a common teapot, meaning an ordinary teapot as distinct from an ornamental silver one. But when we speak of a "common," we mean an open space in a town or village. Wimbledon Common belongs to everybody, it is the "common" property of all the inhabitants of London. One meaning of "common" is therefore "belonging to all." We can easily apply this meaning to the term Common Factor. Take the numbers 9 and 15.

The factors of 9 are 1, 3, 9
" " 15 are 1, 3, 5, 15.

Obviously 3 is a common factor of 9 and 15.

Consider the numbers 35 and 36. The factors of 35 are 1, 5, 7, 35; the factors of 36 are 1, 2, 3, 4, 6, 9, 12, 18, 36. Apart from 1, which is a common factor in any numbers, there are no common factors here.

The factors of 20 are 1, 2, 4, 5, 10, 20. 20 is said to be a MULTIPLE of each factor. A multiple of a number contains the number an exact number of times. 30 is a multiple of 2, of 5, of 10, of 15. Is 17 a multiple of 8? 17 contains 8 twice, but there is a remainder: 17, therefore, is not a multiple of 8. EVEN NUMBERS are multiples of 2, *i.e.* they divide exactly by 2. Thus 2, 4, 6, 8, 10, 12, 14, 16, &c. are even numbers. ODD NUMBERS are not multiples of 2. Thus 1, 3, 5, 7, 9, 11, 13, &c. are odd numbers. If n represents any integer, then $2n$ is always an even number, and $2n+1$ is always an odd number.

Write down a few multiples of 3. These are 3, 6, 9, 12, 15, 18, 21, 24, &c.

Write down a few multiples of 5. These are 5, 15, 20, 25, 30, 35, &c.

Study the multiples of 3 and 5 and find whether 3 and 5 have a *common* multiple, *i.e.* a multiple common to both. 15 is a common multiple of 3 and 5, and it is known as the Least Common Multiple of 3 and 5, or more usually, the L.C.M. of 3 and 5.

Find the Least Common Multiple of 2, 3, and 4.

Multiples of 2 are 2, 4, 6, 8, 10, **12**, 14, 16, 18, &c.

Multiples of 3 are 3, 6, 9, **12**, 15, 18, 21, 24, 27, &c.

Multiples of 4 are 4, 8, **12**, 16, 20, 24, 28, 32, 36, &c.

The least multiple common to the three lots is 12. 12 is called the L.C.M. of 2, 3, and 4.

To find the L.C.M. of 12 and 20 we write down the prime factors of each number.

$$12 = 2 \times 2 \times 3$$
$$20 = 2 \times 2 \times 5.$$

Now the multiple required must contain 12 or $2 \times 2 \times 3$, and it must contain 20 or $2 \times 2 \times 5$. The multiple will contain the factors 2 twos, 1 three, 1 five. Hence L.C.M. of 12 and 20 is $2 \times 2 \times 3 \times 5$ or 60.

Find the L.C.M. of 4, 7, 12, 13, 25, 36.

$$4 = 2 \times 2$$
$$7 = 1 \times 7$$
$$12 = 2 \times 2 \times 3$$
$$13 = 1 \times 13$$
$$25 = 5 \times 5$$
$$36 = 2 \times 2 \times 3 \times 3.$$

The largest number of twos is 2; the L.C.M. will thus contain 2×2. The largest number of threes is 2 (in 36): the L.C.M. will contain 2 threes or 3×3. The largest number of fives is 2 (in 25): the L.C.M. must therefore contain 5×5. It will also contain a 7 and a 13. Hence L.C.M. of 4, 7, 12, 13, 25, and 26 is $2 \times 2 \times 3 \times 3 \times 5 \times 5 \times 7 \times 13$ or 81900.

What is the L.C.M. of 30, 32, 36, 40?

$$30 = 2 \times 3 \times 5$$
$$32 = 2 \times 2 \times 2 \times 2 \times 2$$
$$36 = 2 \times 2 \times 3 \times 3$$
$$40 = 2 \times 2 \times 2 \times 5.$$

The greatest number of twos is 5 (in 32); the

greatest number of threes is 2 (in 36); of fives, 1. Hence L.C.M. of 30, 32, 36, and 40 is $2 \times 2 \times 2 \times 2 \times 2 \times 3 \times 3 \times 5$ or 1440.

The Greatest Common Measure.—The word *Measure* is often used for the word *Factor*, and the Greatest Common Measure or the G.C.M., as it is called, is sometimes spoken of as the Highest Common Factor or the H.C.F.

Take the numbers 105 and 180. The factors of 105 are $3 \times 5 \times 7$; the factors of 180 are $2 \times 2 \times 3 \times 3 \times 5$. The Common Factors are 3 and 5. Now 3 is a factor common to both numbers, but it is not the *highest* factor common to both. Neither is 5. But 3×5 or 15 is a factor of 105 and of 180. 15 is the Highest Common Factor, the H.C.F. or the G.C.M.

Find the Greatest Common Measure of 840 and 945.

Find the factors of 840 by dividing by 2 as often as you can, then by 3, 5, and so on, thus:

$$\begin{array}{r|l} 2 & 840 \\ \hline 2 & 420 \\ \hline 2 & 210 \\ \hline 3 & 105 \\ \hline 5 & 35 \\ \hline 7 & 7 \\ \hline & 1 \end{array}$$

The factors of 840 are $2 \times 2 \times 2 \times 3 \times 5 \times 7$.

Do likewise with 945. There is no use in beginning to divide by 2 in this case, for when the unit digit of a number (in this case 5) is odd the whole number is odd; in other words, it is not a multiple of 2.

$$\begin{array}{r|l} 3 & 945 \\ \hline 3 & 315 \\ \hline 3 & 105 \\ \hline 5 & 35 \\ \hline 7 & 7 \\ \hline & 1 \end{array}$$

The factors of 945 are $3 \times 3 \times 3 \times 5 \times 7$.

We place the factors together and by bold type show up the common factors.

$$840 = 2 \times 2 \times 2 \times \mathbf{3} \times \mathbf{5} \times \mathbf{7}$$
$$945 = 3 \times 3 \times \mathbf{3} \times \mathbf{5} \times \mathbf{7}.$$

The common factors are 3, 5, and 7. The Highest Common Factor or Greatest Common Measure of 840 and 945 is $3 \times 5 \times 7$ or 105.

In practice we may find the G.C.M. in the following way. Find the G.C.M. of 1313 and 2121. We divide the greater by the less—

$$\begin{array}{r} 1313\ )\ 2121\ (\ 1 \\ \underline{1313} \\ 808 \end{array}$$

and get 808 as remainder. We use this 808 as a new divisor, and the old divisor 1313 as a new dividend:

$$\begin{array}{r} 808\ )\ 1313\ (\ 1 \\ \underline{808} \\ 505 \end{array}$$

Again we use the remainder 505 as a divisor and the divisor 808 as a dividend:

$$\begin{array}{r} 505\ )\ 808\ (\ 1 \\ \underline{505} \\ 303 \end{array}$$

303 is the next divisor and 505 the next dividend, and so on. The whole process is this:

$$\begin{array}{l} 1313\ )\ 2121\ (\ 1 \\ \qquad\ \ \underline{1313} \\ \qquad\ \ \ 808\ )\ 1313\ (\ 1 \\ \qquad\qquad\quad\ \ \underline{808} \\ \qquad\qquad\quad\ \ 505\ )\ 808\ (\ 1 \\ \qquad\qquad\qquad\qquad\ \underline{505} \\ \qquad\qquad\qquad\qquad\ 303\ )\ 505\ (\ 1 \\ \qquad\qquad\qquad\qquad\qquad\quad \underline{303} \\ \qquad\qquad\qquad\qquad\qquad\quad 202\ )\ 303\ (\ 1 \\ \qquad\qquad\qquad\qquad\qquad\qquad\quad\ \underline{202} \\ \qquad\qquad\qquad\qquad\qquad\qquad\quad\ 101\ )\ 202\ (\ 2 \\ \qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad \underline{202} \end{array}$$

The last divisor 101 is the G.C.M. or H.C.F.

A neater method is to arrange thus:

1	1313	2121	1
	808	1313	
1	505	808	1
	303	505	
2	202	303	1
	202	202	
	0	101	

In algebra we follow the same method. Find the H.C.F. of x^2-4x+3 and $4x^3-9x^2-15x+18$. Arrange thus:

$x-1$	x^2-4x+3	$4x^3-\ \ 9x^2-15x+18$	$4x+7$
	x^2-3x	$4x^3-16x^2+12x$	
	$-x\ +3$	$7x^2-27x+18$	
	$-x\ +3$	$7x^2-28x+21$	
		$x-3$	

$x-3$ is the H.C.F.

Time is saved by the use of detached coefficients. The H.C.F. of x^2+5x+6 and $x^2+6x \times 8$ is found thus:

	x^2+5x+6	x^2+6x+8	
$1+3$	$1\ +5\ +6$	$1\ +6\ +8$	1
	$1\ +2$	$1\ +5\ +6$	
	$3\ +6$	$1\ +2$	
	$3\ +6$		

$1+2$ is the H.C.F., but 1 is $1x$, $\therefore x+2$ is the H.C.F.

Find the H.C.F. of $2x^2-8xy+6y^2$ and $3x^2-14xy+15y^2$.

$$2x^2-8xy+6y^2\ )\ 3x^2-14xy+15y^2\ ($$

It is evident that we cannot divide $3x^2$ by $2x^2$, but we observe that the divisor cancels by 2, and becomes $x^2-4xy+3y^2$.

$$\begin{array}{l|l|l}
-x+7 & x^2-4xy+3y^2 & 3x^2-14xy+15y^2 \\
 & \underline{x^2-3xy} & \underline{3x^2-12xy+\ 9y^2} \\
 & -xy\ +3y^2 & -2xy\ +6y^2 \\
 & \underline{-xy\ +3y^2} & \text{Cancel remainder by } 2y, \text{ then it becomes } -x+3y.
\end{array}$$

The H.C.F. is $-x+3y$ or $3y-x$.

Proof of the Rule for Finding the H.C.F.—Suppose we have two numbers, A and B. Divide A by B and call the quotient p and the remainder C. Divide B by C and call the quotient q and the remainder D. Divide C by D and call the quotient r.

$$\begin{array}{l}
\mathrm{B}\ )\ \mathrm{A}\ (\ p \\
\quad \underline{p\mathrm{B}} \\
\qquad \mathrm{C}\ )\ \mathrm{B}\ (\ q \\
\qquad\quad \underline{q\mathrm{C}} \\
\qquad\qquad \mathrm{D}\ )\ \mathrm{C}\ (\ r \\
\qquad\qquad\quad \underline{r\mathrm{D}}
\end{array}$$

Observe that $A=pB+C$
$B=qC+D$
$C=rD$ (since there is no remainder).

Now D is our H.C.F., *i.e.* it is the highest common factor of A and B. We must therefore prove that D is a factor of A and also a factor of B. D goes into C r times without remainder, therefore D is a factor of C. If it is a factor of C it will also be a factor of q times C or qC. (If this is difficult to see, take a simple instance: If 4 is a factor of 12 it is also a factor of 9 times 12.) Again, since D is a factor of qC it is also a factor of $q\mathrm{C}+\mathrm{D}$ or B. (For example 7 is a factor of 28 and it is a factor of 28+7.) We have found that D is a factor of B and of C. It will therefore be a factor of $p\mathrm{B}+\mathrm{C}$ or A. Hence D is a common factor of A and B. We have yet to show that it is the *highest* common factor.

Suppose D is not the highest common factor of A and B. Suppose K is a higher common factor. If K is a factor of A and B it is also a factor of $3\mathrm{A}+4\mathrm{B}$ or $10\mathrm{A}+19\mathrm{B}$ or $m\mathrm{A}+n\mathrm{B}$; so also it is a factor of $7\mathrm{A}-2\mathrm{B}$, or $10a-6\mathrm{B}$, or $m\mathrm{A}-n\mathrm{B}$. Hence K is a factor of $m\mathrm{A}\pm n\mathrm{B}$. Now K is a factor of $\mathrm{A}-p\mathrm{B}$, but $\mathrm{A}-p\mathrm{B}=\mathrm{C}$, hence K is a common factor of B and C. It must be a factor of $\mathrm{B}-10\mathrm{C}$, or $\mathrm{B}-n\mathrm{C}$ or $\mathrm{B}-qc$, &c. But $\mathrm{B}-q\mathrm{C}=\mathrm{D}$. Therefore K is a common factor of C and D. But it cannot be a factor of D, since we supposed K to be a common factor of A and B higher than the common factor D. Hence K is not a higher factor than D. Then D is the highest common factor of A and B.

Realising the difficulty a beginner has in dealing with letters instead of figures, we give the above working in figures. Let A be 943 and B be 851.

$$\begin{array}{l}
\mathrm{B}=851\ )\ \mathrm{A}=943\ (\ p=1 \\
\quad \underline{p\mathrm{B}=851} \\
\qquad \mathrm{C}=92\ )\ \mathrm{B}=851\ (\ q=9 \\
\qquad\quad \underline{q\mathrm{C}=828} \\
\qquad\qquad \mathrm{D}=\ 23\ )\ \mathrm{C}=92\ (\ r=4 \\
\qquad\qquad\quad \underline{rd=92} \\
\qquad\qquad\qquad 0
\end{array}$$

Now it is clear that $\mathrm{A}(943)=p\mathrm{B}(851)+\mathrm{C}(92)$
and $\mathrm{B}(851)=q\mathrm{C}(828)+\mathrm{D}(23)$.

It is evident that D(23) is a factor of C(92) and that D(23) is a factor of qC(828 or 9 times 92).

We shall now try to prove that the product of any two numbers is equal to the product of their L.C.M. and G.C.M.

Let K be their H.C.F. Then A will be so many times K, say a times K, and B will be say b times K.

Then $\mathrm{A}=a\mathrm{K}$ and $\mathrm{B}=b\mathrm{K}$.

For if A be 49 and B be 42, the H.C.F. K is 7.

Now 49(A) = 7(a) times 7(K) and 42(B) = 6(b) times 7(K). a and b (7 and 6 in our arithmetical example) cannot have a common factor else K would not be the H.C.F., and their L.C.M. must be their product $a\times b$ or ab. The lowest common multiple of aK(A) and bK(B) must be $ab\times\mathrm{K}$ or abK. Hence L.C.M. of A and B is abK. Call it S.

Now we have two numbers, A and B, having as their H.C.F. K and their L.C.M. S.

We saw that $\mathrm{A}=a\mathrm{K}$ and $\mathrm{B}=b\mathrm{K}$ and $\mathrm{S}=ab\mathrm{K}$.

$$\begin{aligned}
\text{Now product of A and B} &= \mathrm{A}\times\mathrm{B} \\
&= a\mathrm{K}\times b\mathrm{K} \\
&= \mathrm{K}\times ab\mathrm{K} \\
&= \mathrm{K}\times\mathrm{S} \\
\therefore\ \mathrm{AB} &= \mathrm{KS}.
\end{aligned}$$

Hence the product of two numbers is equal to their L.C.M. multiplied by their G.C.M.

Consider KS = AB. If we divide equals by equals the remainders are equal. Divide each by K

Then $$\frac{\mathrm{KS}}{\mathrm{K}}=\frac{\mathrm{AB}}{\mathrm{K}}$$

or $$\mathrm{S}=\frac{\mathrm{AB}}{\mathrm{K}}$$

but S was the L.C.M. of A and B
AB „ product „
K „ H.C.F. „

Hence the L.C.M. of two numbers is found by dividing their product by their G.C.M. (or H.C.F.).

Again if we divide KS = AB each by S, we have:

$$\frac{\mathrm{KS}}{\mathrm{S}}=\frac{\mathrm{AB}}{\mathrm{S}}$$

or $$\mathrm{K}=\frac{\mathrm{AB}}{\mathrm{S}}$$

That is, the H.C.F. of two numbers is found by dividing their product by their L.C.M.

Suppose we want to find the L.C.M. of 770 and 2431. We can find the G.C.M. thus :

6	770	2431	3
	726	2310	
1	44	121	2
	33	88	
	11	33	3
		33	

The G.C.M. is 11.

$$\text{L.C.M.} = \frac{\text{product of numbers}}{\text{G.C.M.}}$$

$$= \frac{\overset{70}{\cancel{770}} \times 2431}{\cancel{11}}$$

$$= 170170.$$

The equation : product of two numbers = their L.C.M. multiplied by their G.C.M. holds good *only for two numbers.*

FACTORS IN ALGEBRA

The factors of ab are a and b, since $ab = a \times b$. So also the factors of $12x^2y^3$ are $12 \times x^2 \times y^3$

$$\text{or } 12 \times x \times x \times y \times y \times y$$
$$\text{or } 2 \times 2 \times 3 \times x \times x \times y \times y \times y.$$

What are the factors of $3x^2 - 4xy$?

The factors of $3x^2$ are $3 \times x \times x$
,, ,, $4xy$ are $4 \times x \times y$

Obviously x is a factor common to $3x^2$ and $4xy$. $3x^2 - 4xy$ can be written as $x(3x - 4y)$; the common factor x has been set apart. $x(3x - 4y)$ means that $3x - 4y$ is to be multiplied by x.

$$\begin{array}{l} 3x - 4y \\ \underline{x \qquad\quad} \\ \underline{3x^2 - 4xy.} \end{array}$$

Find the factors of $5x^4y - 15x^2y^2$.

The factors of $5x^4y$ are $\cancel{5} \times \cancel{x} \times \cancel{x} \times x \times x \times \cancel{y}$
,, ,, $15x^2y^2$ are $3 \times \cancel{5} \times \cancel{x} \times \cancel{x} \times \cancel{y} \times y$

The common factors (crossed out) are :

$$5 \times x \times x \times y = 5x^2y.$$

We divide $5x^4y - 15x^2y^2$ by $5x^2y$

$$\begin{array}{l} 5x^2y\ )\ 5x^4y - 15x^2y^2\ (\ x^2 - 3y \\ \qquad\quad \underline{5x^4y - 15x^2y^2} \end{array}$$

$$5x^4y - 15x^2y^2 = 5x^2y(x^2 - 3y).$$

The factors of $19ab^2c^2 + 38a^2bc$ are $19abc(bc + 2a)$, for

$$19ab^2c^2 = \cancel{19} \times \cancel{a} \times \cancel{b} \times b \times \cancel{c} \times c$$
$$\text{and} \qquad 38a^2bc = 2 \times \cancel{19} \times \cancel{a} \times a \times \cancel{b} \times \cancel{c}.$$

The common factors are $19 \times a \times b \times c$ or $19abc$. Take away this common factor and note the factors not crossed out. They are $b \times c$ or bc and $2 \times a$ or $2a$.

Factorise $3x^2 - 6x^3y + 9xy^2$.

The common factor is $3x$. Divide the expression by $3x$ and you have $x - 2x^2y + 3y^2$.

$$\therefore \quad 3x^2 - 6x^3y + 9xy^2 = 3x(x - 2x^2y + 3y^2).$$

Write down the factors of $x^2 + 2xy + y^2$. We do this from memory. The factors are $(x+y)(x+y)$ since $x^2 + 2xy + y^2 = (x+y)^2$.

Consider $(x+y)^2 = x^2 + 2xy + y^2$. $x \times x$ gives x^2, and $y \times y$ gives y^2. That is easy to understand. How do we account for the $2xy$? $2xy$ is 2 times $x \times y$.

Thus to square $n + \text{K}$, we at once see that n squared will be n^2, and K squared will be K^2; the mid term will be twice $n \times \text{K} = 2n\text{K}$.

$$\therefore (n + \text{K})^2 = n^2 + 2n\text{K} + \text{K}^2.$$

Suppose we have to find the factors of $16x^2 + 40xy + 25y^2$. We see at once that $16x^2$ is the square of $4x$, and that $25y^2$ is the square of $5y$. In all probability the expression is $(4x + 5y)^2$, but we must make sure. When we study $(a+b)^2 = a^2 + 2ab + b^2$ we find that the middle term $2ab$ is $2 \times a \times b$, or twice the product of a and b. But in $4x + 5y$ $4x$ takes the place of a, $5y$ takes the place of b. Twice the product of $4x$ and $5y$ is $2 \times 4x \times 5y$ or $40xy$. So that $16x^2 + 40xy + 25y^2 = (4x + 5y)^2$.

Find the factors of $64x^2 - 144xy + 81y^2$.

$$64x^2 = (8x)^2 \text{ and } 81y^2 = (9y)^2.$$

Knowing that $(a-b)^2 = a^2 - 2ab + b^2$ we guess that $64x^2 - 144xy + 81y^2 = (8x - 9y)^2$. But we must make sure. The middle term $-2ab$ is twice the product of a and $-b$ or $2 \times a \times -b$. So the mid term of $(8x - 9y)^2$ must be $2 \times 8x \times -9y$, that is $-144xy$.

Hence $64x^2 - 144xy + 81y^2 = (8x - 9y)^2$.

Factorise $4x^2 - 9y^2$. We know that $a^2 - b^2 = (a+b)(a-b)$, and we see at once that $4x^2 - 9y^2 = (2x + 3y)(2x - 3y)$.

Find the factors of $x^2 + 2xy + y^2 - z^2$. At a glance we see that $x^2 + 2xy + y^2 = (x+y)^2$. We rewrite the expression as $(x+y)^2 - z^2$. Now $a^2 - b^2 = (a+b)(a-b)$. If we call $x + y$ K, $(x+y)^2 - z^2$ becomes $\text{K}^2 - z^2 = (\text{K} + z)(\text{K} - z)$. Substitute the values for K, and $(\text{K}+z)(\text{K}-z)$ becomes $(x + y + z)(x + y - z)$. The working should be arranged thus :

$$\begin{aligned} x^2 + 2xy + y^2 - z^2 &= (x+y)^2 - z^2 \\ &= \{(x+y)+z\}\{(x+y)-z\} \\ &= (x+y+z)(x+y-z). \end{aligned}$$

A more difficult case of factorisation is this : find the factors of $x^4 + x^2y^2 + y^4$. $(a+b)^2 = a^2 + 2ab + b^2$ and $(a^2+b^2)^2 = a^4 + 2a^2b^2 + b^4$.

So $(x^2 + y^2)^2 = x^4 + 2x^2y^2 + y^4$.

$$\begin{aligned} \text{Now } x^4 + x^2y^2 + y^4 &= x^4 + (2x^2y^2 - x^2y^2) + y^4 \\ &= (x^4 + 2x^2y^2 + y^4) - x^2y^2 \\ &= (x^2 + y^2)^2 - (xy)^2 \\ &= (x^2 + y^2 + xy)(x^2 + y^2 - xy) \\ &= (x^2 + xy + y^2)(x^2 - xy + y^2). \end{aligned}$$

Factorise a^4-b^4.

$$a^4-b^4=(a^2+b^2)(a^2-b^2)$$
$$=(a^2+b^2)(a+b)(a-b).$$

Factorise x^8-y^8.

$$x^8-y^8=(x^4+y^4)(x^4-y^4)$$
$$=(x^4+y^4)(x^2+y^2)(x^2-y^2)$$
$$=(x^4+y^4)(x^2+y^2)(x+y)(x-y).$$

All the above depend on these three facts :

(1) $(m+n)^2=m^2+2mn+n^2$
(2) $(m-n)^2=m^2-2mn+n^2$
(3) $(m+n)(m-n)=m^2-n^2$.

(1) and (2) are perfect squares, (3) is the difference of two squares (m^2 and n^2).

When we find the factors of $x^2+11x+30$ we are not dealing with perfect squares. x^2 is a perfect square, being $x\times x$, but 30 is not a perfect square. 30 must be split into two factors. One pair of factors is 3 and 10. Suppose we jump to the hasty conclusion that the factors of x^2 being $x\times x$, and the factors of 30 being 3 and 10, the expression $x^2+11x+30$ $=(x+3)(x+10)$.

If these are the factors, $(x+3)$ multiplied by $(x+10)$ will give $x^2+11x+30$. Let us see. Imagine they are arranged like this,
$$\begin{array}{r} x+\ 3. \\ \underline{x+10} \end{array}$$
Mentally we multiply $x+3$ by x and we get x^2+3x; mentally we multiply $x+3$ by 10 and we get $10x+30$. The whole product is therefore $x^2+3x+10x+20$, or $x^2+13x+20$. But the middle term should be $11x$; hence $(x+3)(x+10)$ are not the factors of $x^2+11x+30$.

Try 15 and 2, which make another pair of 30's factors. Then $x^2+11x+30$ may be equal to $(x+15)(x+2)$. Multiplying out mentally we find that the middle term is $+17x$; and we are trying to get $+11x$ as middle term.

Try again. 6 and 5 are factors of 30. $(x+6)$ $(x+5)$ gives $x^2+11x+30$. Hence $(x+6)(x+5)$ are the factors of $x^2+11x+30$.

What are the factors of $a^2+30a+81$?

The factors of a^2 are $a\times a$, the factors of 81 are 9×9. The factors may be $(a+9)(a+9)$ or $(a+9)^2$. Let us see. $a\times a=a^2$, and $+9\times 9$ $=81$. The middle term is $2\times a\times 9$ or $18a$. $(a+9)^2=a^2+18a+81$. $(a+9)^2$ cannot be equal to $a^2+30a+81$. Our factors are wrong somewhere. It is unlikely that the first one can be wrong, for a^2 must here be factorised as $a\times a$. We must find other factors for 81. Try 3×27.

Suppose the factors are $(a+3)(a+27)$. Multiply out : $a^2+3a+27a+81=a^2+30a+81$. Thus $(a+3)(a+27)$ are the factors of a^2+30a $+81$.

Factorise $K^2+10K-39$. The factors of K^2 are $K\times K$; the factors of -39 are $-13\times +3$ or $-3\times +13$.

Let us guess that the factors of $K^2+10K-39$ are $(K-13)(K+3)$. Multiply out : K^2-13K $+3K-39=K^2-10K-39$. But we want $+10K$. The factors of $K^2+10K-39$ are therefore $(K+13)(K-3)$.

If we divide a^3+b^3 by $a+b$ we have a^2-ab+b^2 as quotient, and if we divide a^3-b^3 by $a-b$, the quotient is a^2+ab+b^2.

Memorise these identities.

$$a^3+b^3=(a+b)(a^2-ab+b^2)$$
$$a^3-b^3=(a-b)(a^2+ab+b^2).$$

Factorise x^3+27y^3.

x^3 is the cube of x. Call x a
$27y^2$ „ „ $3y$. Call $3y$ b.

Then $a^3+b^3=(a+b)(a^2-ab+b^2)$.

But every a here stands for x, every b for $3y$.
so $(a+b)(a^2-ab+b^2)=(x+3y)\{x^2-x\cdot 3y+ 3y)^2\}$
$=(x+3y)(x^2-3xy+9y^2)$.

Factorise $125p^3-27q^3$.

$125p^3$ is the cube of $5p$. Call $5p$ a
$27q^3$ „ „ $3q$. Call $3q$ b.

Then $a^3-b^3=(a-b)(a^2+ab+b^2)$.

Substitute for a and b, then

$(5p)^3-(3q)^3=\{5p-3q\}\{(5p)^2+5p\cdot 3q+(3q)^2\}$
or $125p^3-27q^3=(5p-3q)(25p^2+15pq+9q^2)$.

Factorise $1+8x^3$. This may be thought of as 1^3+8x^3, since $1^3=1\times 1\times 1=1$.

$1^3=$ the cube of 1. Call it a
$8x^3=$ „ $2x$. Call it b.
$a^3+b^3=(a+b)(a^2-ab+b^2)$.

But $a=1$ and $b=2x$. Substitute these values for a and b.

$(1)^3+(2x)^3=\{1+2x\}\{(1)^2-1\cdot 2x+(2x)^2\}$
or $1+8x^3=(1+2x)(1-2x+4x^2)$.

If $x+y$ be cubed, then $(x+y)^3$ or $(x+y)(x+y)$ $(x+y)$ is found to equal $x^3+3x^2y+3xy^2+y^3$. Similarly $(x-y)^3$ is found to be $x^3-3x^2y+3xy^2-$ y^3. Note that in both cases the powers of x descend, while the powers of y ascend.

Memorise $\underline{(x+y)^3}=\underline{x^3+3x^2y+3xy^2+y^3}$.

The signs are all positive.

Memorise $\underline{(a-b)^3}=\underline{a^3-3a^2b+3ab^2-b^3}$.

The signs are alternately negative and positive.

Suppose I am asked to write down the cube of $4x+5y$. I call $4x$ a and $5y$ b.

Then $(a+b)^3=a^3+3a^2b+3ab^2+b^3$.

I substitute the correct values for a and b : then

$(4x+5b)^3=(4x)^3+3(4x)^2(5y)+3(4x)(5y)^2+(5y)^3$
$=64x^3+240x^2y+300xy^2+125y^3$

Similarly $(4x-5b)^3=64x^3-240x^2y+300xy^2-$ $125y^3$.

The factors of $m^3+3m^2n+3mn^2+n^3$ are $(m+n)^3$. The factors of $m^3-3m^2n+3mn^2-n^3$ are $(m-n)^3$. We write these down from memory. Let us try to factorise $m^3+3m^2n+3mn^2+n^3$,

using the method we have already learned. Arrange the expression thus:

$$(m^3+n^3)+(3m^2n+3mn^2).$$

We discovered that $m^3+n^3=(m+n)(m^2-mn+n^2)$. We can see that in $(3m^2n+3mn^2)$ $3mn$ is a common factor. Let us rearrange the expression:

$$\begin{aligned}m^3+3m^2n+3mn^2+n^3&=(m^3+n^3)+(3m^2n+3mn^2)\\&=(m+n)(m^2-mn+n^2)+\\&\quad 3mn(m+n).\end{aligned}$$

In an expression like $ak+al$ we say a is a factor common to ak and al, and we take it apart thus: $ak+al=a(k+l)$. So in $(m+n)(m^2-mn+n^2)+3mn(m+n)$ we can see that $m+n$ is a factor common to $(m+n)(m^2-mn+n^2)$ and to $3mn(m+n)$. Take the common factor apart.

$$\begin{aligned}&\text{Then } (m+n)(m^2-mn+n^2)+3mn(m+n)\\&=(m+n)(m^2-mn+n^2+3mn)\\&=(m+n)(m^2+2mn+n^2)\\&\therefore m^3+3m^2n+3mn^2+n^3=(m+n)(m^2+2mn+n^2).\end{aligned}$$

To factorise $8x^3-36x^2y+54xy^2-27y^3$ we might arrange thus:

$$(8x^3-27y^3)-(36x^2y-54xy^2)$$

and factorise each part.

Factorise $ab+bc+ax+cx$. b is a factor of the first two terms, x is a factor of the last two terms.

$$\begin{aligned}\text{Thus } ab+bc+ax+cx&=(ab+bc)+(ax+cx)\\&=b(a+c)+x(a+c).\end{aligned}$$

$a+c$ is a factor of both terms: take it out. Then expression $=(a+c)(b+x)$.

Factorise $x^2y-ax-xy^2+ay$.

Rearrange: $x^2y-xy^2-ax+ay$.

Place brackets round each pair:

$$\begin{aligned}&(x^2y-xy^2)-(ax-ay)\\&=xy(x-y)-a(x-y).\end{aligned}$$

$x-y$ is a common factor: take it out. Expression $=(x-y)(xy-a)$.

Examination Tests in Factorisation.—(1) Square $a+b+c$. Write expression as $a+(b+c)$ and call $(b+c)$ k. Then $a+(b+c)$ becomes $a+k$, $(a+k)^2=a^2+2ak+k^2$.

Substitute value for k. Then

$$\begin{aligned}(a+b+c)^2&=a^2+2a(b+c)+(b+c)^2\\&=a^2+2ab+2ac+b^2+2bc+c^2\\&=a^2+b^2+c^2+2ab+2bc+2ca.\end{aligned}$$

(2) Simplify $\dfrac{x^2+ax-bx-ab}{x^2+ax-cx-ac}$.

(L. C. lower, 1913.)

This is a fraction. Factorise the numerator.

$$\begin{aligned}x^2+ax-bx-ab&=(x^2+ax)-(bx+ab)\\&=x(x+a)-b(x+a)\\&=(x+a)(x-b).\end{aligned}$$

Denominator $x^2+ax-cx-ac$

$$\begin{aligned}&=(x^2+ax)-(cx+ac)\\&=x(x+a)-c(x+a)\\&=(x+a)(x-c).\end{aligned}$$

Hence $\dfrac{x^2+ax-bx-ab}{x^2+ax-cx-ac}=\dfrac{(x+a)(x-b)}{(x+a)(x-c)}=\dfrac{x-b}{x-c}$

since we can cancel numerator and denominator by their common factor $x+a$.

EQUATIONS

An *equation* is a statement that one algebraical expression is equal to another. Thus $(a+b)(a-b)=a^2-b^2$ is an equation. The *left* side of the equation is $(a+b)(a-b)$; the *right* side is a^2-b^2. Whatever the values of a and b, the above equation is always true. Hence the name *identity* is given to this type of equation. Familiar identities are:

$$\begin{aligned}&(a+b)^2=a^2+2ab+b^2\\&(a-b)^2=a^2-2ab+b^2\\&(a+b)^3=a^3+3a^2b+3ab^2+b^3\\&(a-b)^3=a^3-3a^2b+3ab^2-b^3\\&a^3+b^3=(a+b)(a^2-ab+b^2)\\&a^3-b^3=(a-b)(a^2+ab+b^2)\\&a^4-b^4=(a^2+b^2)(a^2-b^2)=(a^2+b^2)(a+b)(a-b).\end{aligned}$$

Consider the equation $x+4=9$. This equation is true only when $x=5$, and it is known as an *Equation of Condition.* Where a symbol has a definite value, as in $x+4=9$, where $x=5$, the symbol is called an UNKNOWN QUANTITY. The process of finding the value of the unknown quantity (which is usually x, but sometimes y or z) is called *Solving the Equation.* The value of the unknown quantity is known as the ROOT of the equation.

When the unknown quantity in an equation is of the first power, the equation is known as a SIMPLE EQUATION—*e.g.* $x-9=17$ is a simple equation. When the unknown quantity is of the second power, *e.g.* x^2, the equation is called a QUADRATIC EQUATION.

Solution of Simple Equations.—Solve $4x=12$.

We know that if equals are divided by equals the quotients are equal. We want to find the value of the unknown quantity x. What shall we do to $4x$ to get x? Obviously divide it by 4. If we divide each side by 4, the equation is not altered in value. $\dfrac{4x}{4}=\dfrac{12}{4}$ or $x=\dfrac{12}{4}=3$.

Solve $x+4=5$. If we subtract equals from equals the remainders are equal. Take 4 from each side of the equation.

$$\begin{aligned}\text{Then}\quad &x+4-4=5-4\\&\text{or } x=5-4=1.\end{aligned}$$

Solve $x-9=19$. Our endeavour in solving a simple equation is to change it so that x alone remains on the left side. We have to get rid

of -9. If we add $+9$ to -9 we get 0. Hence we add $+9$ to each side of the equation.

$$x-9+9=16+9$$
$$\text{or } x=16+9=25.$$

Solve $2x+8=12$. Subtract 8 from each side.

Then $2x+8-8=12-8$
or $2x=12-8$
$=4.$

Divide each side by 2.

Then $x=2.$

Solve $11x-2=5x+10$. In every equation the unknown quantity must be on the left side. $5x$ is on the right side, and we must take it out of that position. If we subtract $5x$ from the right side, we must also subtract $5x$ from the left side. Taking $5x$ from each side we have:

$$11x-2-5x=5x+10-5x$$

or $6x-2=10.$

But we want nothing but x on the left side; the -2 must be taken away. Add $+2$ to each side.

Then $6x-2+2=10+2.$
or $6x=10+2$
$=12$

$\therefore$ $x=2.$

Solve $-3x-5=-7x+1$. The $-7x$ on the right must disappear. If we add $+7x$ to it we get 0, but we must also add $+7x$ to the left side.

Then $-3x-5+7x=-7x+1+7x$

or $7x-3x-5=1+7x-7x$

$\therefore$ $4x-5=1.$

Add $+5$ to each side.

Then $4x-5+5=1+5$
$4x=6$
$x=\frac{6}{4}$
$=\frac{3}{2}$
$=1\frac{1}{2}.$

Solve $2x-3=3x-7$. Add $-3x$ to each side.

Then $2x-3-3x=3x-7-3x$

or $2x-3x-3=-7+3x-3x$
$-x-3=-7.$

Add to each side $+3$

Then $-x-3+3=-7+3$

or $-x=-4.$

Multiply each side by -1.

Then $-x\times-1=-4\times-1$

or $+1x=+4$
or $x=4.$

The above solutions show that you can transpose a term, *i.e.* take it from one side of an equation to the other by simply writing it on the opposite side with its sign changed.

$$4x+9=16.$$

Transpose $+9$, that is, write it down on the right side but with its sign changed.

$$4x=16-9.$$

Transpose the terms in

$$4x+7=3x+9.$$

Transpose $+3x$ to left side and it becomes $-3x$.

Transpose $+7$ to right side, and it becomes -7.

$$4x-3x=9-7$$
$$\text{or } x=2.$$

Harder Simple Equations.—Solve $(x+3)(x-4)=(x+4)(x-6)$.

Multiply out each side

Then $x^2-x-12=x^2-2x-24.$

Subtract x^2 from each side

Then $-x-12=-2x-24.$

Transpose, then $-x+2x=-24+12$
or $x=-12.$

Solve the equation $bx-c=ax-d$. Transpose $-c$ and $+ax$, so that the left side contains x terms only.

$$bx-ax=c-d.$$

Factorise left side

$$x(b-a)=(c-d).$$

Divide each side by $b-a$

Then $\frac{x\overset{1}{(b-a)}}{\underset{1}{(b-a)}}=\frac{c-d}{b-a}$

$\therefore$ $x=\frac{c-d}{b-a}$

Solve the equation $(x-1)(x-3)=(x-2)(x-4)$
(L.C. lower, 1913.)

Multiply out each side.

Then $x^2-4x+3=x^2-6x+8.$

Subtract x^2 from each side.

Then $-4x+3=-6x+8.$

Transpose $6x-4x=8-3$
$2x=5$ divide each side by 2
$x=2\frac{1}{2}.$

Prove your answer by substituting $2\frac{1}{2}$ for each x in the equation.

Left side $(x-1)(x-3)=(2\frac{1}{2}-1)(2\frac{1}{2}-3)$
$=1\frac{1}{2}\times-\frac{1}{2}$
$\frac{3}{2}\times-\frac{1}{2}$
$=-\frac{3}{2\times2}$
$=-\frac{3}{4}.$

Right side $(x-2)(x-4)=(2\frac{1}{2}-2)(2\frac{1}{2}-4)$
$=\frac{1}{2}\times-1\frac{1}{2}$
$=-\frac{1}{2}\times\frac{3}{2}$
$=-\frac{3}{4}.$

Solve $\frac{x+5}{6}-\frac{x+1}{9}=\frac{x+3}{4}$

The L.C.M. of 6, 9, and 4 is 36.

Equation is $\frac{6(x+5)}{36}-\frac{4(x+1)}{36}=\frac{9(x+3)}{36}$.

Multiply each side by 36. Then

$$\frac{6(x+5)\times\cancel{36}}{\cancel{36}}-\frac{4(x+1)\times\cancel{36}}{\cancel{36}}=\frac{9(x+3)\times\cancel{36}}{\cancel{36}}$$

becomes $6(x+5)-4(x+1)=9(x+3)$.

Remove brackets, $6x+30-4x-4=9x+27$.

Transpose, $6x-4x-9x=27-30+4$.

$$-7x=1 \text{ (multiply each side by } -1)$$
$$7x=-1 \text{ (divide each side by 7)}$$
$$x=-\tfrac{1}{7}.$$

Problems involving Simple Equations.—A boy is 12 years old, how old will he be in 4 years? We say 12 years + 4 years = 16 years. Now suppose a boy is x years old (where x is an unknown quantity), how old will he be in 4 years? Obviously $x+4$ years old.

In all problems we must think of a simple instance in arithmetic. The sum of two numbers is 18 and their difference is 4, what are the numbers? The numbers are *unknown quantities*. Let us call the less number x. Now since the difference between the numbers is 4, the greater number will be $x+4$. Here we have our two numbers x and $(x+4)$. But we are told their sum is 18.

Hence
$$x+(x+4)=18$$
$$x+x+4=18$$
$$2x=18-4$$
$$=14$$
$$x=7.$$

Then $x+4=7+4=11$.

The numbers are 7 and 11.

Divide 27 shillings between A and B, so that A gets 7 shillings more than B.

Let x shillings be B's share. Then $x+7$ shillings is A's share. But the two shares together make 27 shillings.

$$\therefore \quad x+x+7=27$$
$$2x=27-7$$
$$=20$$
$$\therefore \quad x=10.$$

B's share is 10*s.*, A's share is 10*s.* + 7*s.* or 17*s.*

Divide 197 into two parts, such that 4 times the greater exceeds 5 times the less by 50.

Let x be the lesser part. Then $197-x$ will be the greater part. Now 4 times the greater part, *i.e.* $4(197-x)$ exceeds 5 times the lesser part, *i.e.* $5x$ by 50. In other words $4(197-x)$ is equal to $5x+50$.

$$4(197-x)=5x+50$$
$$788-4x=5x+50$$
$$-4x-5x=50-788$$
$$-9x=-738$$
$$9x=738$$
$$x=82.$$

82 is the lesser part. The greater part is $197-82$ or 115.

A father is 4 times as old as his son; in 24 years he will only be twice as old as his son. What are their ages?

Let x years be the son's age now, then $4x$ years is the father's age now. In 24 years the son's age will be $x+24$ years and the father's age will be $4x+24$ years. But we are told that 24 years hence the father will be twice as old as his son.

$\therefore$ father's age in 24 yrs. = twice son's age in 24 years.

i.e.
$$4x+24=\text{twice }(x+24)$$
$$=2(x+24)$$
$$=2x+48.$$

Transpose, then $4x-2x=48-24$
$$2x=24$$
$$x=12.$$

Son's age is 12, and since father is 4 times as old, father's age is 48.

Find three consecutive numbers such that if they are divided by 10, 17, and 26 respectively, the sum of the quotients is 10.

Remember that consecutive numbers differ by 1. 4, 5, 6, 7, are consecutive and can be written 4, 4+1, 4+2, 4+3. So consecutive numbers after x are $x+1$, $x+2$, $x+3$, $x+4$, &c.

In our problem let x be the first number, then $x+1$ is the second, and $x+2$ the third.

The first is divided by 10; $x\div 10=\frac{x}{10}$

The second is divided by 17; $x+1\div 17=\frac{x+1}{17}$

The third is divided by 26; $x+2\div 26=\frac{x+2}{26}$

And we are told that the sum of the quotients is 10. Hence $\frac{x}{10}+\frac{x+1}{17}+\frac{x+2}{26}=\frac{10}{1}$. The L.C.M. is really $17\times 13\times 10$, but let us take the product of the denominators instead, *i.e.* $10\times 17\times 26$. Then

$$\frac{x\times 17\times 26}{10\times 17\times 26}+\frac{(x+1)\times 10\times 26}{10\times 17\times 26}+\frac{(x+2)\times 10\times 17}{10\times 17\times 26}=\frac{10\times 10\times 17\times 26}{10\times 17\times 26}$$

Multiply each fraction by $10\times 17\times 26$. Then

$$\{x\times 17\times 26\}+\{(x+1)\times 10\times 26\}+\{(x+2)\times 10\times 17\}=\{10\times 10\times 17\times 26\}.$$

Multiply out. Then

$$442x+260x+260+170x+340=44200$$
$$872x=44200-260-340$$
$$=43600$$
$$x=50.$$

Numbers are x, $x+1$, $x+2$

i.e. 50, 50+1, 50+2

or 50, 51, 52.

The numerator of a fraction is 5 less than the denominator. If 5 be added to the numerator and 9 to the denominator the fraction equals $\frac{1}{2}$. Find the fraction.

The denominator is 5 *more* than the numerator. Let x be the numerator, then $x+5$ is the denominator. Add 5 to the numerator and the new numerator is $x+5$. Add 9 to the denominator and the new denominator is $(x+5)+9$ or $x+14$. Hence the new fraction is $\frac{x+5}{x+14}$. But we are told this fraction equals $\frac{1}{2}$.

Our equation, therefore, is $\frac{x+5}{x+14}=\frac{1}{2}$

Multiply both sides by $x+14$, and you have:

$$\frac{(x+5)\times(x+14)}{x+14}=\frac{x+14}{2}$$

or $$x+5=\frac{x+14}{2}$$

Multiply each side by 2.

Then $$2(x+5)=x+14$$

or
$$\begin{aligned}2x+10&=x+14\\ x&=14-10\\ &=4.\end{aligned}$$

The fraction required is $\frac{x}{x+5}$

But $x=4$.

$\therefore$ fraction is $\frac{4}{4+5}$ or $\frac{4}{9}$.

Simultaneous Equations.—In Simple Equations we dealt with one unknown quantity, x. In Simultaneous equations we deal with *two* or more unknown quantities, x, y, z, &c.

$x+y=16$ is an equation, but we cannot solve it. If $x=2$ we can easily find the value of y, for we substitute 2 for x, then $2+y=16$, or $y=16-2=14$.

In the equation $x+y=16$, subtract x from each side, then $x+y-x=16-x$, i.e. $y=16-x$ (1). Whatever value x may have, y is always equal to $16-x$.

If we have a second equation $2x+y=17$, then $y=17-2x$ (2). And if we seek to find a value for y that will satisfy both equations (1) and (2) must be identical:

$$\therefore\quad\begin{aligned}16-x&=17-2x\\ -x+2x&=17-16\\ x&=1.\end{aligned}$$

Our equations are $x+y=16$ and $2x+7=17$. We find x equals 1. Substitute 1 for x in each equation, then $1+y=16$ or $y=15$ and $2+y=17$ or $y=15$. If both equations are to be satisfied, x must equal 1. Two or more equations which are to be satisfied by the same values of the unknown quantities are said to be SIMULTANEOUS EQUATIONS.

Let us try to solve the equations:

$$x+2y=5 \quad \dots \quad (1)$$
$$2x+3y=8 \quad \dots \quad (2)$$

We can rearrange (1) as $x=5-2y$, and having found this value for x, we can substitute it in (2) thus:

$2x+3y=8$ becomes $2(5-2y)+3y=8$

Multiply out, then
$$\begin{aligned}10-4y+3y&=8\\ -y&=8-10\\ &=-2\end{aligned}$$

Multiply each side by -1 and $y=2$

We have found a numerical value for y. We now take one equation—it does not matter which—and substitute 2 for y.

$x+2y=5$ thus becomes $x+2\times5=5$
$$\begin{aligned}\text{or } x+10&=5\\ x&=5-10\\ &=-5.\end{aligned}$$

The roots are $x=--5$ and $y=2$.

The above method is simple, but it is seldom used.

Let us try an easier method. Our aim is to get rid of either x or y for a little. Here are our equations:

$$x+2y=5 \quad \dots \quad (1)$$
$$2x+3y=8 \quad \dots \quad (2)$$

Multiply (1) by 2 and you have $2x+4y=10$. Rewrite the equation thus

$$2x+4y=10 \quad \dots \quad (1)$$
$$2x+3y=8 \quad \dots \quad (2)$$

Subtract (2) from (1).

Then
$$\begin{aligned}(2x+4y)-(2x+3y)&=10-8\\ \cancel{2}x+4y-\cancel{2}x-3y&=2\\ y&=2.\end{aligned}$$

Having found the value of y we get the value of x by substitution.

Solve
$$7x-8y=14 \quad \dots \quad (1)$$
$$2x+7y=20 \quad \dots \quad (2)$$

Multiply (1) by 2 and we have $14x-16y=28$

" (2) " 7 " $14x+49y=140$

Subtract, and $14x-14x=0$. We are thus left with y.

We might have multiplied (1) by 7 and (2) by 8. Thus

$$49x-56y=98$$
$$16x+56y=160.$$

Here if we add, $-56y+56y=0$; we are thus left with $65x=258$, from which we find the value of x.

In solving the equations

$$\frac{x}{9}-\frac{y}{8}=43 \quad \dots \quad (1)$$

$$\frac{x}{8}+\frac{y}{9}=42 \quad \dots \quad (2)$$

we simplify each equation. For instance (1) is $\frac{8x}{72}-\frac{9y}{72}=\frac{43\times72}{72}$ or $8x-9y=3096$.

Solve $5x+2y+3z=18$ . . . . (1)
$2x+2y+\ z=9$ . . . . (2)
$6x+5y+2z=22$ . . . . (3)

Here we have *three* unknown quantities, x, y, and z. We already know how to solve equations involving two unknowns, and in this case we eliminate (take out) one unknown. Study (1) and (2). If we subtract (2) from (1) the y terms will be eliminated for $+2y-2y=0$

$5x+2y+3z=18$ . . . . (1)
$2x+2y+\ z=9$ . . . . (2)

Subtract, then $3x \quad +2z=9$ . . . . (A)

Now eliminate y from (2) and (3).

Multiply (2) by 5 and you have $10x+10y+5z=45$.

Multiply (3) by 2 and you have $12x+10y+4z=44$.

Subtract, then $-2x+z=1$ . . . . (B)

We have found two equations:

$$3x+2z=9$$
$$-2x+\ z=1.$$

Multiply the lower by 2. Then the equations are

$$3x+2z=9$$
$$-4x+2z=2$$

Subtract, then $7x=7$
$x=1$.

Substitute 1 for x in (A). $3x+2z=9$ becomes $3+2z=9$, $\therefore$ $2z=6$ or $z=3$. Take any of the original equations and for every x substitute 1 and for every z substitute 3.

Take (2) $2x+2y+z=9$ becomes
$2+2y+3=9$
$2y=9-3-2$
$=4$

hence $y=2$

The roots of the equation are $x=1$, $y=2$, $z=3$.

Solve $ax+by=bx+ay=a+b$. (L.C. lower 1913.)

Consider $ax+by=bx+ay$ and arrange so that the x terms are on the left side.

Then $ax-bx=ay-by$.

Factorising we have $x(a-b)=y(a-b)$. Divide each side by $a-b$, then $\dfrac{x(a-b)}{a-b}=\dfrac{y(a-b)}{a-b}$.

Cancel by $(a-b)$ and $x=y$.

Now consider $ax+by=a+b$, x can be substituted for y, hence

$$ax+bx=a+b$$

or

$$x(a+b)=a+b.$$

Divide each side by $a+b$.

Then $\dfrac{x(a+b)}{a+b}=\dfrac{a+b}{a+b}$, cancel by $a+b$

and $x=1$

But $x=y$ $\therefore$ $y=1$.

Solve the following equation:

$x+y+1=3(x+y-1)$ . . . (1)
$x-y+1=2(x-y-1)$ . . . (2)

(Cambridge Local Exams., 1904).

Simplify each equation.

(1) is $x+y+1=3x+3y-3$

or $-2x-2y=-4$ divide by $+2$ and it becomes
$-x-\ y=-2$ . . . . (A)

(2) is $x-y+1=2x-2y-2$

or $-x+y=-3$ . . . . (B)

Write the simplified equations thus:

$-x-y=-2$ . . . . (A)
$-x+y=-3$ . . . . (B)

Subtract, then $-2y=1$. Multiply by -1
$2y=-1$
$y=-\frac{1}{2}$.

Substitute the value for y in (A).

Then $-x-(-\frac{1}{2})=-2$

or $-x+\frac{1}{2}=-2$

$\therefore$ $-x=-2-\frac{1}{2}$
$=-2\frac{1}{2}$.

Multiply each side by -1, then $x=2\frac{1}{2}$. The roots are $x=2\frac{1}{2}$ and $y=-\frac{1}{2}$. Prove your answer by substituting the values of x and y in the original equation.

Problems leading to Simultaneous Equations.—Find two numbers such that 3 times the first added to 4 times the second equal 32, and 5 times the first added to 3 times the second equal 35.

Let x be the first number and y the second.

Then $3x+4y=32$ . . . (1)
and $5x+3y=35$ . . . (2)

Multiply (1) by 3 and (2) by 4.

Then $9x+12y=96$
$20x+12y=140.$

Subtract, and $-11x=-44$. Multiply each side by -1, and $11x=44$

$\therefore$ $x=4$.

Find value of y by substituting 4 for x in (1).

$3x+4y=32$ becomes
$12+4y=32$

Transpose: $4y=32-12$
$=20$

$\therefore$ $y=5$.

The numbers are 4 and 5.

A farmer sells to one man 9 horses and 7 cows for £300, and to another 6 horses and 13 cows for the same sum. Find the price of each.

Let x be price of a horse in pounds.
„ y „ „ cow „ „

Then for 9 horses + 7 cows the farmer receives $(9x+7y)$ pounds. But he receives £300,

$\therefore$ $9x+7y=300$ . . . (1)

For 6 horses and 13 cows he receives $(6x+13y)$ pounds; but for 6 horses and 13 cows he gets £300,

$\therefore$ $6x+13y=300$ . . . (2)

Arrange the equation thus:

$$9x + 7y = 300 \quad . \quad . \quad . \quad (1)$$
$$6x + 13y = 300 \quad . \quad . \quad . \quad (2)$$

Multiply (1) by 2 and (2) by 3.

Then $18x + 14y = 600$
$18x + 39y = 900.$

Subtract, and $-25y = -300$. Multiply by -1
$25y = 300$
$y = 12.$

Hence price of cow is £12.

Substitute value of y in (1).

$9x + 7y = 300$ becomes $9x + 84 = 300$

Transpose: $9x = 300 - 84$
$= 216$

or $x = 24.$

Hence price of horse is £24.

One customer buys 8 pounds of apples and 5 pounds of pears for 3/1½; another buys 5 pounds of apples and 9 pounds of pears for 3/8. Find the price of apples and pears per pound. (L.C. lower, 1913.)

Let x be the price in halfpence of a pound of apples.

Let y be the price in halfpence of a pound of pears.

Then $8x + 5y$ is the price in halfpence of 8 pounds of apples and 5 pounds of pears.

$\therefore$ $8x + 5y = 75$

Again $5x + 9y = 88$

The equations are $8x + 5y = 75 \quad . \quad . \quad . \quad (1)$
$5x + 9y = 88 \quad . \quad . \quad . \quad (2)$

Multiply (1) by 5 and (2) by 8.

Then $40x + 25y = 375 \quad . \quad . \quad . \quad (A)$
and $40x + 72y = 704 \quad . \quad . \quad . \quad (B)$

Subtract (A) from (B). $47y = 329$
$y = 7.$

Substitute 7 for y in (1).

$8x + 5y = 75$ becomes
$8x + 35 = 75.$

Transpose, and $8x = 75 - 35$
$= 40$

$\therefore$ $x = 5.$

Hence price of a pound of apples is 5 halfpence or $2\frac{1}{2}d.$, and price of a pound of pears is 7 halfpence or $3\frac{1}{2}d.$

Quadratic Equations.—A quadratic equation contains the square of an unknown quantity. Thus $x = 4$ is a simple equation, but $x^2 = 16$ is a quadratic equation. When the equation does not contain the first power of the unknown quantity it is called a PURE QUADRATIC EQUATION. Thus $x^2 = 25$ is a pure quadratic. When it contains both the first power and the second power of the unknown quantity it is called an ADFECTED QUADRATIC EQUATION. Thus $x^2 + 6x = 9$ is an adfected quadratic.

Pure quadratics are easily solved. In $x^2 = 49$, if we take the square root of each side, then $x = \pm 7$.

Solve the equation $(x+7)^2 = 64$. Take the square root of each side. Then:

$$x + 7 = \pm 8$$

If $x + 7 = +8$
$x = +8 - 7$
$= 1.$

If $x + 7 = -8$
$x = -8 - 7$
$= -15.$

Hence the roots that satisfy the equation $(x+7)^2 = 64$ are 1 and -15.

If the equation is an adfected quadratic it should be solved by factorisation if possible. For example, the equation $x^2 + 24x = 25$ can be written as $x^2 + 24x - 25 = 0$ if we add -25 to each side. Now $x^2 + 24x - 25 = (x+25)(x-1)$, hence $(x+25)(x-1) = 0$, and if the product of factors is zero, one of them must be zero.

$\therefore$ $x - 1 = 0$. Add $+1$ to each side, then $x = 1$.

Again, $x + 25 = 0$. Subtract 25 from each side, then $x + 25 - 25 = 0 - 25$
$\therefore$ $x = -25.$

The roots of the equation are 1 and -25.

Solve $x^2 - 10x = -24$. Transpose, and $x^2 - 10x + 24 = 0$. Factorise: $(x-6)(x-4) = 0$.

Hence $x - 6 = 0$, or $x = 6$
and $x - 4 = 0$, or $x = 4$.

Roots are 6 and 4.

The above quadratic may be done by the method of COMPLETING THE SQUARE.

$$x^2 - 10x = -24.$$

Now $(x-5)^2 = x^2 - 10x + 25$.

Add 25 to each side of the equation.

Then $x^2 - 10x + 25 = -24 + 25$, or $(x-5)^2 = 1$.

Take the square root of each side, and $x - 5 = \pm 1$.

If $x - 5 = +1$
$x = +1 + 5$
$= 6$

If $x - 5 = -1$
$x = -1 + 5$
$= 4.$

Hence $x = 6$ or 4.

Let us discover how a square is completed. $(x+4)^2 = x^2 + 8x + 16$.

The coefficient of x is 8; half the coefficient of x is $\frac{8}{2}$ or 4. And $16 = 4^2$. The last term is thus ($\frac{1}{2}$ coefficient of x)^2.

Try again. $(x+13)^2 = x^2 + 26x + 169$. Is $169 = \frac{1}{2}$(coefficient of x)^2? Coefficient of x is 26; half of 26 is 13. $13^2 = 169$.

Now we know how to complete the square. For instance, given $x^2 + 14x$, complete the square.

The last term $= (\frac{1}{2} \text{ of } 14)^2$
$= 7^2$
$= 49.$

Hence completed square is $x^2 + 14x + 49$, which is $(x+7)^2$.

Solve the equation $x^2+5x-14=0$.

Transpose -14. Then $x^2+5x=14$.

Complete the square x^2+5x+ a third term.

$$\begin{aligned}\text{Third term} &= (\tfrac{1}{2}\text{ coefficient of } x)^2\\ &= (\tfrac{1}{2}\text{ of } 5)^2\\ &= (\tfrac{5}{2})^2\end{aligned}$$

Hence if we add $(\frac{5}{2})^2$ to x^2+5x we make the left side of the equation a perfect square. But if we add $(\frac{5}{2})^2$ to one side we must also add it to the other side.

$$\begin{aligned}\text{Hence } x^2+5x+(\tfrac{5}{2})^2 &= 14+(\tfrac{5}{2})^2\\ &= 14+\tfrac{25}{4}\\ &= \tfrac{56}{4}+\tfrac{25}{4}\\ &= \tfrac{81}{4}.\end{aligned}$$

Take the square root of each side, and

$$x+\tfrac{5}{2} = \pm\tfrac{9}{2}.$$

If $x+\frac{5}{2} = +\frac{9}{2}$, $x=\frac{9}{2}-\frac{5}{2} = \frac{4}{2} = 2$

If $x+\frac{5}{2} = -\frac{9}{2}$, $x = -\frac{9}{2}-\frac{5}{2} = -\frac{14}{2} = -7$.

Hence $x=2$ or -7.

Solve $32-3x^2=10x$.

Transpose, and $32=10x+3x^2$, or $3x^2+10x=32$.

In this case we divide throughout by 3 so as to make the coefficient of x^2 unity.

$$x^2+\tfrac{10}{3}x=\tfrac{32}{3}$$

Complete the square by adding $(\frac{1}{2}$ of $\frac{10}{3})^2$ *i.e.* $(\frac{10}{6})^2$

$$\begin{aligned}x^2+\tfrac{10}{3}x+(\tfrac{10}{6})^2 &= \tfrac{32}{3}+(\tfrac{10}{6})^2\\ &= \tfrac{32}{3}+\tfrac{100}{36}\\ &= \tfrac{384}{36}+\tfrac{100}{36}\\ &= \tfrac{484}{36}\end{aligned}$$

Take square root of both sides

Then $x+\frac{10}{6} = \pm\frac{22}{6}$

If $x+\frac{10}{6} = \frac{22}{6}$, $x=\frac{22}{6}-\frac{10}{6} = \frac{12}{6} = 2$

If $x+\frac{10}{6} = -\frac{22}{6}$, $x = -\frac{22}{6}-\frac{10}{6} = -\frac{32}{6} = -5\frac{2}{6} = -5\frac{1}{3}$.

Hence $x=2$ or $-5\frac{1}{3}$.

Now we may find a solution for a general quadratic equation. Every adfected quadratic is of the form $3x^2+4x+9=0$, or putting symbols for numbers $ax^2+bx+c=0$.

Transpose c, then $ax^2+bx=-c$.

Divide by a so that the coefficient of x^2 may be unity.

$$x^2+\frac{b}{a}x=-\frac{c}{a}$$

Complete the square by adding $(\frac{1}{2}$ coefficient of $x)^2$, *i.e.* $\left(\frac{1}{2}\text{ of }\frac{b}{a}\right)^2$ or $\left(\frac{b}{2a}\right)^2$.

$$\begin{aligned}\text{Then}\quad x^2+\frac{b}{a}x+\left(\frac{b}{2a}\right)^2 &= -\frac{c}{a}+\left(\frac{b}{2a}\right)^2\\ &= -\frac{c}{a}+\frac{b^2}{4a^2}\\ &= \frac{-4ac}{4a^2}+\frac{b^2}{4a^2}\\ &= \frac{-4ac+b^2}{4a^2}\\ &= \frac{b^2-4ac}{4a^2}\end{aligned}$$

Take the square root of each side, and

$$\begin{aligned}x+\frac{b}{2a} &= \pm\sqrt{\frac{b^2-4ac}{4a^2}}\\ &= \pm\frac{\sqrt{b^2-4ac}}{2a}\end{aligned}$$

Transpose and $x = -\dfrac{b}{2a}\pm\dfrac{\sqrt{b^2-4ac}}{2a}$

This is the general formula for the solution of quadratic equations and it should be memorised.

Compare $x^2-3x-5=0$ (A) with $ax^2+bx+c=0$ (B).

a in (B) $=1$ in (A)
b in (B) $=-3$ in (A)
c in (B) $=-5$ in (A).

Since the roots of $ax^2+bx+c=0$ are given by $\dfrac{-b\pm\sqrt{b^2-4ac}}{2a}$, the roots of $x^2-3x-5=0$ are given by

$$\frac{-(-3)\pm\sqrt{(-3)^2-4\times1\times(-5)}}{2\times1}$$

i.e. $\dfrac{3\pm\sqrt{9+20}}{2}$

or $\dfrac{3\pm\sqrt{29}}{2}$

Hence $x=\dfrac{3\pm\sqrt{29}}{2}$

i.e. $x=\dfrac{3+\sqrt{29}}{2}$ or $\dfrac{3-\sqrt{29}}{2}$

Solve the equation $x+5=6(x^2-5)$.
(L.C. higher, 1911.)

Use method of completing the square.

Multiply out, then $x+5=6x^2-30$.

Transpose, and $6x^2-x=35$

Divide by 6 $\quad x^2-\dfrac{x}{6}=\dfrac{35}{6}$

Complete square by adding $\left(\dfrac{1}{12}\right)^2$

Then $$x^2-\frac{x}{6}+\left(\frac{1}{12}\right)^2=\frac{35}{6}+\left(\frac{1}{12}\right)^2$$
$$=\frac{35}{6}+\frac{1}{144}$$
$$=\frac{840}{164}+\frac{1}{144}=\frac{841}{144}.$$

Take square root of each side, then
$$x-\tfrac{1}{12}=\pm\sqrt{\tfrac{841}{144}}$$
$$=\pm\tfrac{29}{12}$$

If $x-\frac{1}{12}=+\frac{29}{12}$
$$x=\tfrac{29}{12}+\tfrac{1}{12}$$
$$=\tfrac{30}{12}$$
$$=2\tfrac{1}{2}$$

If $x-\frac{1}{12}=-\frac{29}{12}$
$$x=-\tfrac{29}{12}+\tfrac{1}{12}$$
$$=-\tfrac{28}{12}$$
$$=-2\tfrac{1}{3}.$$

Hence $x=2\frac{1}{2}$ or $-2\frac{1}{3}$.

Solve the equation $6x^2-13x+6=0$.
(L.C. lower, 1911.)

Factorise, and $(3x-2)(2x-3)=0$.

Since product of two factors equals zero, one of them must be equal to zero.
$$2x-3=0$$
$$2x=3$$
hence $$x=\tfrac{3}{2}=1\tfrac{1}{2}.$$

Again $$3x-2=0$$
hence $$3x=2$$
$$x=\tfrac{2}{3}.$$

Answer $-x=1\frac{1}{2}$ or $\frac{2}{3}$.

Solve the equation $x^2+bc=bx+c^2$.
(L.C. higher, 1912.)

This could be solved by arranging in descending powers of x, thus $x^2-bx+bc-c^2=0$, and substituting the values equivalent to $\frac{\quad}{2a}$ but the shortest way is by factorisation.
$$x^2-bx+bc-c^2=x^2-c^2-bx+bc$$
$$=(x+c)(x-c)-b(x-c)$$
$$=(x-c)(x+c-b).$$

Hence $x^2+bc=bx+c^2$ may be written
$$(x-c)(x+c-b)=0.$$
$$x-c=0\ (1)\text{ and }x+c-b=0\ (2)$$

From (1) we see that $x=c$; from (2) we see that $x=b-c$.

Hence the roots are c and $b-c$.

Solve $6x^2=x+1$ (L.C. lower, 1912.)

Transpose, and $6x^2-x-1=0$

Factorise, and $(3x+1)(2x-1)=0$

$\therefore$ $3x+1=0$ and $2x-1=0$

$\therefore$ $3x=-1$ $\qquad 2x=1$

$x=-\frac{1}{3}$ $\qquad x=\frac{1}{2}$.

Hence $x=\frac{1}{2}$ or $-\frac{1}{3}$.

Solve $(x-1)(x-3)=(x-2)(x-4)$.
(L.C. lower, 1913.)

By multiplying out we find that x^2 disappears, hence the equation is simple, not quadratic.

A neat solution of $\frac{x-1}{x-2}=\frac{x-4}{x-3}$ can be got by adding numerator and denominator to make a new numerator, and subtracting denominator from numerator to make a new denominator

$\frac{2x-3}{1}=\frac{2x-7}{-1}$, multiply each side by -1
$$-1(2x-3)=2x-7$$
$$-2x+3=2x-7$$
$$10=4x$$
$$\therefore\quad x=\tfrac{10}{4}=\tfrac{5}{2}=2\tfrac{1}{2}.$$

Solve $x^2-mx-nx+mn=0$.

Factorise, and
$$x(x-n)-m(x-n)=0$$
$$\therefore\quad (x-m)(x-n)=0$$
hence $$x=m\text{ or }n.$$

For practice, factorise, and
$$x^2-x(m+n)+mn=0,$$
or $$x^2-(m+n)x=-mn \text{ by transposing.}$$

Complete the square of left side by adding $\frac{1}{2}$ the coefficient of x all squared, *i e.* $\left(\frac{m+n}{2}\right)^2$.

Then $$x^2-(m+n)x+\left(\frac{m+n}{2}\right)^2$$
$$=-mn+\left(\frac{m+n}{2}\right)^2$$
$$=-mn+\frac{m^2+2mn+n^2}{4}$$
$$=\frac{-4mn+m^2+2mn+n^2}{4}$$
$$=\frac{m^2-2mn+n^2}{4}$$

Take square root of each side and
$$x-\frac{m+n}{2}=\pm\sqrt{\frac{m^2-2mn+n^2}{4}}$$
$$=\pm\frac{m-n}{2}$$

If $$x-\frac{m+n}{2}=+\frac{m-n}{2}$$
$$x=\frac{m-n}{2}+\frac{m+n}{2}$$
$$=\frac{m-n+m+n}{2}$$
$$=\frac{2m}{2}=m.$$

If $$x-\frac{m+n}{2}=-\frac{m-n}{2}$$
$$x=\frac{m+n}{2}-\frac{m-n}{2}$$
$$=\frac{m+n-(m-n)}{2}$$
$$=\frac{m+n-m+n}{2}$$
$$=\frac{2n}{2}=n.$$

Hence $x=m$ or n.

Solve $x^2-2xk+k^2-b^2=0$.

Left side $=(x-k)^2-b^2$
$=(x-k+b)(x-k-b)=0$.

Hence $x-k+b=0$ or $x-k-b=0$
$\therefore$ $x=k-b$. $\therefore$ $x=k+b$.

Roots are $k+b$ and $k-b$.

Simultaneous Quadratic Equations.—Solve

$$x+y=28 \quad . \quad . \quad . \quad (1)$$
$$xy=187 \quad . \quad . \quad . \quad (2)$$

We could say: Since $xy=187$, $x=\frac{187}{y}$, hence $x+y=28$ becomes $\frac{187}{y}+y=28$, which is a quadratic equation, $187+y^2=28y$.

The better way is to square (1) and multiply (2) by 4.

Then $$(x+y)^2=28^2$$
$$4xy=187\times 4$$

i.e. $$x^2+2xy+y^2=784$$
$$4xy=748.$$

Subtract, and $x^2-2xy+y^2=36$. Take square root of each side, and $x-y=\pm 6$.

Combine $x-y=6$ and $x-y=-6$ with (1).

	$x+y=28$		$x+y=28$
	$x-y=6$		$x-y=-6$
Add, and	$2x=34$	Add, and	$2x=22$
$\therefore$	$x=17$	$\therefore$	$x=11$
Subtract, and	$2y=22$	Subtract, and	$2y=34$
$\therefore$	$y=11$	$\therefore$	$y=17$

Hence $x=17, 11$; $y=11, 17$.

Solve $\frac{x}{a}+\frac{y}{b}=2 \quad . \quad . \quad . \quad (1)$
$$xy=ab \quad . \quad . \quad . \quad (2)$$

Consider (2). Divide each side by a. Then $\frac{xy}{a}=\frac{ab}{a}=b$. Divide each side by y, and $\frac{xy}{ay}=\frac{b}{y}$, i.e. $\frac{x}{a}=\frac{b}{y}$.

Substitute value for $\frac{x}{a}$ in (1).

Then $$\frac{b}{y}+\frac{y}{b}=2$$
$$\frac{b^2+y^2}{by}=2$$
$$b^2+y^2=2by$$
$$b^2-2by+y^2=0$$
$\therefore$ $$(b-y)^2=0$$
i.e. $(b-y)(b-y)=0$.

Hence $y=b$. Substitute this value in (2).

Then $$xb=ab$$
$\therefore$ $$x=a.$$

Answer—$x=a$, $y=b$.

Solve $x^2+y=8 \quad . \quad . \quad . \quad (1)$
$3x+2y=7 \quad . \quad . \quad . \quad (2)$

Here we can multiply (1) by 2 and then subtract (2).

Thus $2x^2+2y=16$
$3x+2y=7$
$\therefore$ $2x^2-3x=9$, a simple quadratic.

Or again, transpose x^2 in (1) and $y=8-x^2$. By substituting this value for y in (2) we have
$$3x+2(8-x^2)=7$$
or $$3x+16-2x^2=7$$
i.e. $$2x^2-3x=9, \text{ \&c.}$$

Solve $x-y=3 \quad . \quad . \quad . \quad (1)$
$x^2+y^2=65 \quad . \quad . \quad . \quad (2)$

Square (1) and subtract (2) from it.
$$x^2-2xy+y^2=9 \quad . \quad . \quad . \quad (a)$$
$$x^2 \quad +y^2=65 \quad . \quad . \quad . \quad (b)$$
$\therefore$ $-2xy=-56$. Multiply by -1.
$$2xy=56.$$

Add $2xy$ to each side of (b).

Then $$x^2+2xy+y^2=65+2xy$$
i.e. $$(x+y)^2=65+56$$
$$=121.$$

Take square root of each side: $x+y=\pm 11$. Combine this with (1).

	$x-y=3$	Again	$x-y=3$
	$x+y=11$		$x+y=-11$
Add, and	$2x=14$	Add, and	$2x=-8$
$\therefore$	$x=7$	$\therefore$	$x=-4$
Subtract, and	$-2y=-8$	Subtract, and	$-2y=14$
	$y=4$		$y=-7$

Hence $x=7$ or -4, $y=4$ or -7.

Equations like Quadratics.—Solve $x^4-13x^2-36=0$.

Factorise, and $(x^2-9)(x^2-4)=0$.
$x^2-9=0$ or $-4=0$
$x^2=9$ $\quad x^2=4$
$x=\pm 3$ $\quad x=\pm 2$

Hence $x=\pm 2$ or ± 3.

Solve $x^6+35x^3+216=0$.

Transpose, and $x^6+35x^3=-216$.

Complete the square:

$$x^6+35x^3+\left(\tfrac{35}{2}\right)^2 = -216+\left(\tfrac{35}{2}\right)^2$$
$$= -216+\tfrac{1225}{4}$$
$$= -\tfrac{864}{4}+\tfrac{1225}{4}$$
$$= \tfrac{361}{4}.$$

Take the square root, and $x^3+\frac{35}{2} = \pm\sqrt{\frac{361}{4}}$
$= \pm\frac{19}{2}$.

If $x^3+\frac{35}{2}=\frac{19}{2}$

$x^3=\frac{19}{2}-\frac{35}{2}$

$= -\frac{16}{2}$

$= -8$

$\therefore \quad x= -2$

If $x^3+\frac{35}{2} = -\frac{19}{2}$

$x^3 = -\frac{19}{2}-\frac{35}{2}$

$= -\frac{54}{2}$

$= -27$

$\therefore \quad x= -3$

Hence $x= -2$ or -3.

A much better method is by factorising.

$$x^6+35x^3+216=(x^3+27)(x^3+8)$$
$$=(x^3+3^3)(x^3+2^3)$$
$$=(x+3)(x^2+3x+9)(x+2)$$
$$(x^2+2x+4), \text{ \&c.}$$

Solve $x-5\sqrt{x}-14=0$.

Let k stand for $\sqrt{x}$, then x or $\sqrt{x}\times\sqrt{x}$ will be k^2.

The equation therefore reads: $k^2-5k-14=0$

Factorise: $(k-7)(k+2)=0$

$\therefore \quad k=7$ or -2.

But $k=\sqrt{x}$, $\therefore \sqrt{x}=7$ or -2

$\therefore \quad x=7^2$ or $(-2)^2$
$=49$ or 4.

$x=49$ obviously satisfies the equation; with the usual convention of signs $x=4$ does not. For $\quad 4-5\sqrt{4}-14=4-10-14$
$= -20$ instead of 0. But observe that $\sqrt{4}$ may be ± 2, and taking the value -2, we have

$$4-5\sqrt{4}-14=4-5\times -2-14$$
$=4+10-14=0$. Note that we obtained $k=\sqrt{x}=-2$, in the working.

Solve $\dfrac{x^2-a^2}{x^2+a^2}+\dfrac{x^2+a^2}{x^2-a^2}=\dfrac{34}{15}$.

Let $\dfrac{x^2-a^2}{x^2+a^2}=k$. Then $\dfrac{x^2+a^2}{x^2-a^2}=\dfrac{1}{\frac{x^2-a^2}{x^2+a^2}}=\dfrac{1}{k}$

Hence equation is $k+\dfrac{1}{k}=\frac{34}{15}$.

Multiply by $15k$: $15k^2+15=34k$.

Transpose: $15k^2-34k+15=0$.

Factorise: $(5k-3)(3k-5)=0$.

Hence $5k-3=0$, *i.e.* $k=\frac{3}{5}$
and $3k-5=0$, *i.e.* $k=\frac{5}{3}$.

Now k is $\dfrac{x^2-a^2}{x^2+a^2}=\dfrac{5}{3}$. Divide numerators by denominators

$$1-\frac{2a^2}{x^2+a^2}=1+\frac{2}{3}.$$ Subtract one from each side,

and $\quad \dfrac{2}{3}=-\dfrac{2a^2}{x^2+a^2}$

or $\quad 2x^2+2a^2= -6a^2$

$\therefore \quad 2x^2= -6a^2-2a^2$
$= -8a^2$

$\therefore \quad x^2= -4a^2$

$\therefore \quad x= \pm a\sqrt{-4}$.

Again, $k=\dfrac{x^2-a^2}{x^2+a^2}=\dfrac{3}{5}$. Add and subtract numerators and denominators

$$\frac{2x^2}{-2a^2}=\frac{8}{-2}$$

$$\overline{-a^2} \quad \overline{-1}$$
$$-x^2= -4a^2$$
$$x^2=4a^2$$
$$x= \pm 2a$$

Hence $x= \pm 2a$, or $\pm a\sqrt{-4}$.

Problems Leading to Quadratic Equations.—A room is 4 feet longer than it is broad, and its area is 480 square feet. Find the length and breadth.

Area = length $\times$ breadth. Let x feet be the breadth. Then $(x+4)$ feet is the length.

Hence $(x)\times(x+4)=\text{area}=480$

i.e. $x(x+4)=480$

$x^2+4x=480$. Complete the square

$$x^2+4x+\left(\tfrac{4}{2}\right)^2=480+\left(\tfrac{4}{2}\right)^2$$
$$=480+2^2$$
$$=480+4$$
$$=484.$$

Take square root of each side, and

$x+\frac{4}{2}= \pm\sqrt{484}$

i.e. $\quad x+2= \pm 22$.

If $x+2=22$

$x=22-2$

$=20$

If $x+2= -22$

$x= -22-2$

$= -24$

Hence $x=20$ or -24.

But x is the breadth, hence length $=20+4$, *i.e.* 24 or $-24+4$, *i.e.* -20. Clearly the value -24 is not suitable. Therefore breadth $=20$ ft. and length $=24$ ft.

The difference of two numbers is 6 and their product is 720. Find the numbers.

Let x be the smaller number. Then $x+6$ will be the greater.

Hence $x(x+6)=720$

or $\quad x^2+6x=720$ an easy quadratic.

What number added to its square root will make 210?

Let x be the number, then $\sqrt{x}$ is its square root, and $x+\sqrt{x}=210$. Solve this equation by substituting k for $\sqrt{x}$, and consequently k^2 for x.

Theory of Quadratic Equations.—We saw that the roots of $ax^2+bx+c=0$ were

$$\frac{\quad}{2a} \text{ and } \frac{-b-\sqrt{b^2-4ac}}{2a}$$

The sum of the roots

$$=\frac{-b+\sqrt{b^2-4ac}}{2a}+\frac{-b-\sqrt{b^2-4ac}}{2a}$$
$$=\frac{-b+\sqrt{b^2-4ac}-b-\sqrt{b^2-4ac}}{2a}$$
$$=\frac{-2b}{2a}$$
$$=\frac{-b}{a}$$
$$=-\frac{b}{a}.$$

If α and β be the roots of the equation

$$\alpha+\beta=\frac{-b}{a}=\frac{\text{coefficient of } x \text{ with sign changed}}{\text{coefficient of } x^2}$$

Again the product of the roots

$$\frac{\quad}{2a} \qquad \frac{\quad}{2a}$$

(Call $\sqrt{b^2-4ac}$ k)

$$=\frac{-b+k}{2a}\times\frac{-b-k}{2a}$$
$$=\frac{b^2+bk-bk-k^2}{4a^2}$$
$$=\frac{b^2-k^2}{4a^2}$$
$$=\frac{b^2-(\sqrt{b^2-4ac})^2}{4a^2}$$
$$=\frac{b^2-b^2+4ac}{4a^2}$$
$$=\frac{4ac}{4a^2}$$
$$=\frac{c}{a}$$

Hence product of roots $=\frac{c}{a}$ or $\alpha\times\beta$, *i.e.* $\alpha\beta=\frac{c}{a}$, *i.e.* the term of the equation not involving x divided by the coefficient of x^2.

Find the sum and product of the roots of the following equations:

(1) $x^2-5x+6=0.$

Let α and β be the roots. Then $\alpha+\beta=+5$, and $\alpha\beta=6$.

(2) $cx^2+bx+a=0$

This is $x^2+\frac{b}{c}x+\frac{a}{c}=0$

$\therefore$ $\alpha+\beta=-\frac{b}{c}$

$\alpha\beta=\frac{a}{c}.$

(3) $6x^2+5x-4=0$, divided by 6 becomes $x^2+\frac{5}{6}x-\frac{4}{6}=0$

$\alpha+\beta=-\frac{5}{6}$

$\alpha\beta=-\frac{4}{6}$

In $ax^2+bx+c=0$, if the roots are α and β.

$\alpha+\beta=-\frac{b}{a}$, and $\alpha\beta=\frac{c}{a}$

Hence $ax^2+bx+c=a\left(x^2+\frac{b}{a}x+\frac{c}{a}\right)$

$=a(x^2-(\alpha+\beta)x+\alpha\beta)$

$=a(x-\alpha)(x-\beta).$

The equation $x^2-5x+6=0$ becomes on factorisation $(x-3)(x-2)=0$, $\therefore$ $x=3$ or 2.

Thus if we are asked to form the equation whose roots are 3 and 2 we write:

$$(x-3)(x-2)=0.$$

So the equation whose roots are 5 and 6 is

$$(x-5)(x-6)=0$$

i.e. $x^2-11x+30=0.$

The equation whose roots are -4 and 6 is

$$(x-(-4))(x-6)=0$$

i.e. $(x+4)(x-6)=0$

i.e. $x^2-2x-24=0.$

Given $-\alpha$ and $-\beta$ as the roots of an equation, find the equation.

Equation is $\{x-(-\alpha)\}\{x-(-\beta)\}=0$

i.e. $(x+\alpha)(x+\beta)=0$

i.e. $x^2+(\alpha+\beta)x+\alpha\beta=0.$

Find the equation whose roots are $b+a$ and $b-a$.

Equation is $\{x-(b+a)\}\{x-(b-a)\}=0$

i.e. $(x-b-a)(x-b+a)=0$

i.e. $(x-b)^2-a^2=0$

i.e. $x^2-2bx+b^2-a^2=0.$

Proof.—Sum of roots

$=b+a+b-a$

$=2b$

$=\frac{\text{coefficient of } x \text{ with sign reversed}}{\text{coefficient of } x^2 \text{ (in this case 1)}}.$

Product of roots $=(b+a)(b-a)$

$=b^2-a^2$

$=$term of equation not containing x.

If α and β be the roots of $x^2+px+q=0$, find the value of $\alpha^2+\beta^2$, and $\frac{\alpha}{\beta}+\frac{\beta}{\alpha}$.

$\alpha+\beta=-p$ $\therefore$ $\alpha^2+2\alpha\beta+\beta^2=p^2$

$\alpha\beta=\quad q$ $\therefore$ $\quad 2\alpha\beta=2q.$

Subtract, and $\alpha^2+\beta^2=p^2-2q.$

Again $\frac{\alpha}{\beta}+\frac{\beta}{\alpha}=\frac{\alpha^2+\beta^2}{\alpha\beta}$

$$=\frac{p^2-2q}{\alpha\beta}$$
$$=\frac{p^2-2q}{q}$$
$$=\frac{p^2}{q}-2.$$

If α and β be the roots of $px^2-qx-r=0$, find the values of $(\alpha+\beta)^2$, $(\alpha-\beta)^2$, and $\alpha^2+\beta^2$.

$$(1) \qquad \alpha+\beta=-\left(-\frac{q}{p}\right)$$
$$=\frac{q}{p}$$

$$(2) \qquad \alpha\beta=-\frac{r}{p}.$$

Square (1) and $\alpha^2+2\alpha\beta+\beta^2=\frac{q^2}{p^2}$ $\therefore$ $\underline{(\alpha+\beta)^2}=\frac{q^2}{p^2}$

Multiply (2) by 4, and $4\alpha\beta=-\frac{4r}{p}$

Subtract, and $\alpha^2-2\alpha\beta+\beta^2=\frac{q^2}{p^2}+\frac{4r}{p}$

i.e. $$\underline{(\alpha-\beta)^2}=\frac{q^2}{p^2}+\frac{4rp}{p^2}$$
$$=\frac{q^2+4rp}{p^2}$$

Again from (1) $\alpha^2+2\alpha\beta+\beta^2=\frac{q^2}{p^2}$ subtract $2\alpha\beta$ from each side, then

$$\alpha^2+\beta^2=\frac{q^2}{p^2}-2\alpha\beta$$
$$=\frac{q^2}{p^2}-2\left(-\frac{r}{p}\right)$$
$$=\frac{q^2}{p^2}+\frac{2r}{p}$$
$$=\frac{q^2+2pr}{}$$

A quadratic equation cannot have more than two roots. For let us suppose the equation $ax^2+bx+c=0$ has 3 different roots, α, β, and γ.

i.e. $x=\alpha$ or β or γ.

Substitute these values, and $ax^2+bx+c=0$ gives

$$a\alpha^2+b\alpha+c=0 \quad \ldots\ldots (1)$$
$$a\beta^2+b\beta+c=0 \quad \ldots\ldots (2)$$
$$a\gamma^2+b\gamma+c=0 \quad \ldots\ldots (3)$$

Subtract (2) from (1).

Then $a(\alpha^2-\beta^2)+b(\alpha-\beta)=0$, divide by $(\alpha-\beta)$ and $a(\alpha+\beta)+b=0$.

Again subtracting (3) from (2) we have

$$a(\beta+\gamma)+b=0.$$

Hence by subtraction

$$a(\alpha+\beta)-a(\beta+\gamma)=0$$
$$a\alpha+a\beta-a\beta-a\gamma=0$$
$$a(\alpha-\gamma)=0$$

Thus $a=0$ or $\alpha-\gamma=0$

$\therefore$ $\alpha=\gamma$.

Now a is not zero in the equation $ax^2+bx+c=0$, nor is root $\alpha=$ root γ, since the three roots α, β, and γ were given as being different. Hence there cannot be 3 different roots.

We found that the roots of $ax^2+bx+c=0$ were $\frac{-b\pm\sqrt{b^2-4ac}}{2a}$. If b^2 is greater than $4ac$ then b^2-4ac is positive quantity, and therefore $\sqrt{b^2-4ac}$ is real. And the roots $\frac{-b+\sqrt{b^2-4ac}}{2a}$ or α (say) and $\frac{-b-\sqrt{b^2-4ac}}{2a}$ or β (say) are real and unequal.

If $b^2=4ac$, $b^2-4ac=0$, $\therefore$ $\sqrt{b^2-4ac}=0$.

In this case α becomes $\frac{-b+0}{2a}$ or $\frac{-b}{2a}$ and β becomes $\frac{-b-0}{2a}$ or $\frac{-b}{2a}$, hence when $b^2=4ac$ $\alpha=\beta$, the roots are real and equal.

If b^2 is less than $4ac$, then b^2-4ac is negative and $\sqrt{b^2-4ac}$ is an imaginary quantity, hence α and β are in this case both imaginary.

If b^2-4ac is a perfect square $\sqrt{b^2-4ac}$ must be rational, and α and β are rational and unequal.

Note the meanings of these terms, *rational*, &c. 6 is *real*, $\sqrt{5}$ is real, for we can take the square root of 5, but it is *irrational*, as no exact value can possibly be assigned to it. $\sqrt{-5}$ is unreal or *imaginary*, for we cannot find the square root of -5. Again 6 is rational, $\sqrt{16}$ is rational, so also are $4\frac{1}{2}$, $-\frac{3}{4}$.

RATIO AND PROPORTION

Ratio is the relation between one quantity and another of the same kind. The relationship between 3 lb. and 7 lb. is expressed by the fraction $\frac{3}{7}$; we say 3 lb. are $\frac{3}{7}$ of 7 lb. There can be no relationship between quantities that are not of the same kind. We say 7 ducks are $\frac{7}{8}$ of 8 ducks, but we cannot say 9 ducks are $\frac{9}{10}$ of 10 swans. A ratio is always a number; in fact, a ratio is a fraction. The ratio 6 to 7 is written $\frac{6}{7}$. The numerator is called the *antecedent*, the denominator the *consequent*. Now we know that a fraction is not altered in value if its numerator and denominator are each multiplied by the same number.

$$\frac{6\times2}{7\times2}=\frac{12}{14}. \qquad \frac{10}{11}=\frac{10\times7}{11\times7}=\frac{70}{77}.$$

When two ratios are equal to each other the terms are said to be in PROPORTION. Thus since $\frac{6}{7}=\frac{12}{14}$, $\frac{6}{7}=\frac{12}{14}$ is a proportion, and it is usually written 6 : 7 : : 12 : 14 or 6 : 7 = 12 : 14, which is read as "6 is to 7 as 12 is to 14." The numbers 6 and 14 are called the EXTREMES, the numbers 7 and 12 are called the MEANS. Note where the extremes and means are when the proportion is written $\frac{6}{7}=\frac{12}{14}$. This is

$$\frac{\text{The extreme 6}}{\text{The mean 7}}=\frac{\text{The mean 12.}}{\text{The extreme 14}}$$

Generally, then, if A and B are two numbers, $\frac{A}{B}=\frac{pA}{pB}$ where p is any number.

Consider $\frac{6}{7}=\frac{12}{14}$. Multiply each by 14. Then

$$\frac{6\times 14}{7}=\frac{12\times\cancel{14}}{\cancel{14}}=12.$$

Now multiply each side by 7. Then

$$\frac{6\times 14\times\cancel{7}}{\cancel{7}}=12\times 7$$

or $\qquad 6\times 14=12\times 7.$

But 6 and 14 are the extremes, and 12 and 7 are the means, hence the product of the extremes = the product of the means.

Thus if $\qquad \frac{A}{B}=\frac{K}{S}$

$$A\times S=K\times B$$

or $\qquad AS=BK.$

Again consider the proportion $\frac{A}{B}=\frac{K}{S}$.

Divide each side by K.

Then $\qquad \frac{A}{B\times K}=\frac{\cancel{K}}{S\times\cancel{K}}$

or $\qquad \frac{A}{B\times K}=\frac{1}{S}.$

Now multiply each side by B.

Then $\qquad \frac{A\times\cancel{B}}{\cancel{B}\times K}=\frac{1\times B}{S}$

or $\qquad \frac{A}{K}=\frac{B}{S}.$

So from $\frac{5}{6}=\frac{20}{24}$ we have $\frac{5}{20}=\frac{6}{24}$.

Quantities are said to be in CONTINUED PROPORTION when the first is to the second as the second is to the third, the third to the fourth, and so on. Thus a, b, c, d, e, f are in continued proportion when $\frac{a}{b}=\frac{b}{c}=\frac{c}{d}=\frac{d}{e}=\frac{e}{f}$.

Consider the first two ratios.

$$\frac{a}{b}=\frac{b}{c}, \text{ or } a:b::b:c$$

We know that the product of the means is equal to the product of the extremes. Hence

$$a\times c=b\times b$$

or $\qquad ac=b^2.$

In the above case b is said to be a MEAN PROPORTIONAL between a and c. And c is said to be a THIRD PROPORTIONAL to a and b.

Let us experiment with $\frac{a}{b}=\frac{b}{c}$. Multiply each side by a and divide by b.

Then $\qquad \frac{a}{b}\times\frac{a}{b}=\frac{b}{c}\times\frac{a}{b}$

or $\qquad \frac{a^2}{b^2}=\frac{ab}{bc}=\frac{a}{c}$

$\therefore \qquad a:c::a^2:b^2.$

Let us experiment with the proportion $\frac{a}{b}=\frac{c}{d}$. Already we know that $ad=bc$, and $\frac{a}{c}=\frac{b}{d}$. Let us divide 1 by each ratio.

Then $\qquad 1\div\frac{a}{b}=1\div\frac{c}{d}$

i.e. $\qquad 1\times\frac{b}{a}=1\times\frac{d}{c}$

$\therefore \qquad$ if $\frac{a}{b}=\frac{c}{d}$, then $\frac{b}{a}=\frac{d}{c}$. Hence $\frac{b}{d}=\frac{a}{c}$

Let us add 1 to each side.

Then $\qquad \frac{a}{b}+1=\frac{c}{d}+1$

or $\qquad \frac{a+b}{b}=\frac{c+d}{d} \quad . \quad . \quad . \quad (1)$

Let us subtract 1 from each side.

Then $\qquad \frac{a}{b}-1=\frac{c}{d}-1$

$$\frac{a-b}{b}=\frac{c-d}{d} \qquad (2)$$

Divide the left side of (1) by the left side of (2), and the right side of (1) by the right side of (2).

Then $\qquad \frac{a+b}{b}\div\frac{a-b}{b}=\frac{c+d}{d}\div\frac{c-d}{d}$

r $\qquad \frac{a+b}{\cancel{b}}\times\frac{\cancel{b}}{a-b}=\frac{c+d}{\cancel{d}}\times\frac{\cancel{d}}{c-d}$

r $\qquad \frac{a+b}{a-b}=\frac{c+d}{c-d}$

Consider the ratio $\frac{\frac{2}{3}}{\frac{4}{5}}$.

Divide numerator $\frac{2}{3}$ by denominator $\frac{4}{5}$

Then $\qquad \frac{\frac{2}{3}}{\frac{4}{5}}=\frac{2}{3}\div\frac{4}{5}$

$$=\frac{2}{3}\times\frac{4}{5}$$

$$=\frac{2\times 5}{3\times 4}$$

So $\qquad \frac{b}{\frac{x}{y}}=\frac{ay}{bx}$

Find a fourth proportional to 3, 4, and 6.

Let the fourth proportional be x.

Then $$3 : 4 :: 6 : x$$

or $$\frac{3}{4}=\frac{6}{x}$$

Multiply extreme by extreme and mean by mean.

Then $$3x=6\times 4=24$$

$\therefore$ $$x=8.$$

The proportion is $\frac{3}{4}=\frac{6}{8}$.

Find a mean proportional to $4a$ and $16a$.

When $\frac{a}{b}=\frac{b}{c}$ (a is to b as b is to c), b is said to be a mean proportional of a and c. Let the mean proportional to $4a$ and $16a$ be x.

Then $$\frac{4a}{x}=\frac{x}{16a}$$
$$x\times x=16a\times 4a$$
$$x^2=64a^2.$$

But $x^2=x\times x=x$ squared, and $64a^2=8a\times 8a=8a$ squared. Hence by taking the square root of each side
$$x=8a.$$

The proportion therefore is $\frac{4a}{8a}=\frac{8a}{16a}$.

If $\frac{2a}{3b}=\frac{3c}{4d}=\frac{5d}{7e}$, prove that $\frac{2a+3c+5d}{3b+4d+7e}=\frac{2a+5d}{3b+7e}$

Let $\frac{2a}{3b}=\frac{3c}{4d}=\frac{5d}{7e}=k$, where k is a CONSTANT—that is, a quantity that does not change. Then, since $\frac{2a}{3b}=k$, $2a=3bk$; since $\frac{3c}{4d}=k$, $3c=4dk$; since $\frac{5d}{7e}=k$, $5d=7ek$. Substitute these values thus:

$$\frac{2a+3c+5d}{3b+4d+7e}=\frac{3bk+4dk+7ek}{3b+4d+7e}$$
$$=\frac{k(3b+4d+7e)}{3b+4d+7e}$$
$$=k.$$

Substitute the values for $2a$ and $5d$ in $\frac{2a+5d}{3b+7e}$.

Then $$\frac{2a+5d}{3b+7e}=\frac{3bk+7ek}{3b+7e}$$
$$=\frac{k(3b+7e)}{3b+7e}$$
$$=k.$$

Hence $\frac{2a+3c+5d}{3b+4d+7e}=\frac{2a+5d}{3b+7e}$, since each is equal to k.

If $\frac{ax}{b-c}=\frac{by}{c-a}=\frac{cz}{a-b}$, show that $ax+by+cz=0$.

(Medical Prelim., Scotland, 1909.)

Let $\frac{ax}{b-c}=\frac{by}{c-a}=\frac{cz}{a-b}=k$, where k is a constant.

Then $$\frac{ax}{b-c}=k,\ \therefore\ ax=k(b-c)$$
$$\frac{by}{c-a}=k,\ \therefore\ by=k(c-a)$$
$$\frac{cz}{a-b}=k,\ \therefore\ cz=k(a-b)$$

Substitute values for ax, by, and cz in $ax+by+cz$.

Then $$ax+by+cz=k(b-c)+k(c-a)+k(a-b)$$
$$=kb-kc+kc-ka+ka-kb$$
$$=0.$$

Proportion in Arithmetic.—If 6 horses cost £120, what will 7 horses cost ?

We can solve this problem by a common-sense method. We can find what 1 horse costs

6 horses cost £120
1 horse costs £120 ÷ 6, or £20
7 horses cost £20 × 7, or £140

This is known as the method of UNITARY PROPORTION.

The other method is as follows. 6 horses are to 7 horses as £120 are to cost of 7 horses, or $\frac{6 \text{ horses}}{7 \text{ horses}}=\frac{£120}{\text{cost of 7 horses}}$, or $\frac{6 \text{ horses}}{7 \text{ horses}}=\frac{£120}{£x}$ if £x be the cost of 7 horses

Then $$6x=120\times 7$$
$$x=\frac{120\times 7}{6}$$
$$=20\times 7$$
$$=140$$

Hence $$\frac{6}{7}=\frac{120}{140}$$

7 horses cost £140

If I can travel 100 miles for 8s., how far can I travel for 23s. ?

For 8s. I can travel 100 miles

„ 1s. „ $\frac{100}{8}$ miles

„ 23s. „ $\frac{100}{8}\times 23$ miles

or $\frac{\cancel{100}\times 23}{2}$ miles

i.e. $\frac{575}{2}$ miles

or $287\frac{1}{2}$ miles.

Or by proportion :

8*s*. is to 23*s*. as 100 miles is to x miles.

$$\frac{8}{23}=\frac{100 \text{ miles}}{x}$$

$$8x=100\times 23 \text{ miles}$$
$$=2300 \quad ,,$$
$$x=\frac{2300}{8} \quad ,,$$
$$=287\tfrac{4}{8} \quad ,,$$
$$=287\tfrac{1}{2} \quad ,,$$

The unitary method leads to what is called the fractional method. Let us solve the following problem by the unitary method.

14 men build a wall in 10 days, how many men will be required to build the wall in 7 days ?

When the wall is built in 10 days we require 14 men.

When the wall is built in 1 day we require 14×10 men.

When the wall is built in 7 days we require

This may be written 14 men $\times\frac{10}{7}$, *i.e.* 20 men.

Instead of finding how many men are required to build the wall in 1 day, we reason thus : 14 men take 10 days ; we want to do the work in 7 days, that is, in *less time* than before. We shall require more men. Now we may write the ratio of 10 days to 7 days as $\frac{10}{7}$ and the ratio of 7 days to 10 days as $\frac{7}{10}$. Our 14 men must be multiplied either by $\frac{10}{7}$ or by $\frac{7}{10}$. If we multiply 14 by $\frac{7}{10}$ we get *less* than 14, if by $\frac{10}{7}$ we get *more* than 14. But we want more than 14 men, hence we multiply 14 men by $\frac{10}{7}$.

16 apples cost 1*s*. 2*d*. ; how many apples should I get for 7*s*. ?

We cannot express 1*s*. 2*d*. as a ratio of 7*s*., but we can express 14 pence as a ratio of 84 pence thus $\frac{14}{84}$ or 84 pence as a ratio of 14 pence thus $\frac{84}{14}$. Our answer is to be so many apples. We must multiply our 16 apples either by $\frac{14}{84}$ or by $\frac{84}{14}$. Obviously our answer will be *more* than 16 apples.

Hence we multiply 16 by $\frac{84}{14}$.

Let x be the number of apples unknown

Then $x=\frac{16\times\overset{6}{\cancel{84}}}{\cancel{14}}$ apples

$=96$ apples.

If 4000 horses eat 3000 quarters of oats in 24 days, how long will 8 bushels last 2 horses ?

Our answer will be so many, say, x days. Note the ratios.

$$\frac{4000 \text{ horses}}{2 \text{ horses}},\ \frac{2 \text{ horses}}{4000 \text{ horses}}$$

$$\frac{3000 \text{ qtrs.}}{8 \text{ bshls.}} \text{ which is } \frac{3000 \text{ qtrs.}}{1 \text{ qtr.}} \text{ or } \frac{1 \text{ qtr.}}{3000 \text{ qtrs.}}$$

How long will 1 quarter last if 3000 quarters last 24 days ? Obviously fewer days.

Hence multiply 24 days by $\frac{1}{3000}$.

How long will oats last 2 horses if they last 4000 horses for 24 days ? Obviously a much larger time ; hence we multiply 24 days by 4000

Then $x=24 \text{ days}\times\frac{1}{3000}\times\frac{4000}{}$

$=\frac{\overset{4}{\cancel{\overset{8}{\cancel{24}}}}\times 1\times\cancel{4000}}{\cancel{3000}\times\cancel{2}}$ days

$=16$ days.

The above problem solved by the unitary method is as follows :

4000 horses eat 3000 quarters in 24 days.

1 horse eats 3000 quarters in 24×4000 days.

1 horse eats 1 quarter in $\frac{24\times 4000}{3000}$ days.

2 horses eat 1 quarter in $\frac{\cancel{24}\times\cancel{4000}}{\cancel{3000}\times\cancel{2}}$ days.

or 16 days.

Application of Proportion to Solution of Equations.—

Solve $\frac{2x+3}{3x+9}=\frac{2x-8}{3x-13}$.

If $\frac{A}{B}=\frac{K}{S}$, $\frac{A}{K}=\frac{B}{S}$.

Since $\frac{2x+3}{3x+9}=\frac{2x-8}{3x-13}$

$\frac{2x+3}{2x-8}=\frac{3x+9}{3x-13}$.

Divide each numerator by its denominator

Then $1+\frac{11}{2x-8}=1+\frac{22}{3x-13}$

Subtract 1 from each side

Then $$\frac{11}{2x-8}=\frac{22}{3x-13}$$

Divide each fraction by 11.

and $$\frac{\overset{1}{\cancel{11}}}{(2x-8)\times\cancel{11}}=\frac{\overset{2}{\cancel{22}}}{(3x-13)\times\cancel{11}}.$$

$$\frac{1}{2x-8}=\frac{2}{3x-13}.$$

Multiply mean by mean and extreme by extreme and $3x-13=2(2x-8)$

$$=4x-16$$

$$3x-4x=-16+13$$

and $$-x=-3$$

$$\therefore \quad x=3.$$

Solve $$\frac{2x+3}{x+1}=\frac{4x+5}{4x+4}+\frac{3x+3}{3x+1}.$$

Divide numerators by denominators

$$2+\frac{1}{x+1}=1+\frac{1}{4x+41}+1+\frac{}{3x+1}$$

Subtract 2 from each side.

$$\frac{1}{x+1}=\frac{1}{4x+4}+\frac{2}{3x+1}$$

Transpose $\frac{1}{4x+4}$

$$\frac{}{x+1}-\frac{1}{4x+4}=\frac{2}{3x+1}$$

$$\frac{1}{x+1}-\frac{1}{4(x+1)}=\frac{2}{3x+1}$$

$$\frac{4-1}{4(x+1)}=\frac{2}{3x+1}$$

$$\frac{3}{4x+4}=\frac{2}{3x+1}$$

$$9x+3=8x+8$$

$$x=5.$$

SIMPLE INTEREST

Interest is money paid for the loan of money. If I put £100 in a bank the bank pays me, say, £3 each year for the loan of my £100. This £3 is said to be simple interest. How can the bank afford to pay me interest ? The bank is not keeping my £100 in a safe ; it is lending my money to Mr. Brown who is building a house. Mr. Brown is not a rich man, and he really cannot afford to build a house. But he goes to the banker and says : "Look here, I want to build a house, but I haven't got enough money. Will you lend me £100 ?" The banker replies : "All right, I shall lend you £100 but you must pay for the loan of it ; you must pay me £6 every year." The bank is paying interest to me for lending it £100 ; Mr. Brown is paying interest to the bank for lending him £100. If I put £100 in the bank this £100 is called my PRINCIPAL. The £3 paid to me each year by the bank is called the INTEREST. Interest is always reckoned as a PERCENTAGE, that is, so much interest for every £100. Thus the above bank pays 3 per cent. interest, and this is often written 3%. So also Mr. Brown is paying 6 per cent interest to the bank.

Suppose I want to know what interest I shall receive if I allow the bank to keep my £100 for 4 years at 3 per cent. simple interest :

At the end of the	1st year	I receive	£3	interest
„ „	2nd year	„	£3	„
„ „	3rd year	„	£3	„
„ „	4th year	„	£3	„

Obviously I have £12 of interest.

I put £400 in a bank that pays 4 per cent. per annum. What interest do I receive in 7 years ?

For each £100 I receive £4 interest per annum; for 4 times £100 or £400 I receive £4 $\times\frac{400}{100}$ or £4 $\times$4 per annum, *i.e.* £16 per annum. Hence in 7 years I receive £16 $\times$7 or £112 as interest.

Put it in this way :

£100 in 1 year brings me £4 interest.

£100 $\times$4 in 1 year brings me £4 $\times\frac{400}{100}$ or £4 $\times$4 interest.

£400 in 7 years brings me £4 $\times$4 $\times$7 or £112 interest.

If I put a principal—call it P—into a bank that pays me a rate (call it R) per cent. per annum, what interest do I receive after a few years—say T years ?

£100 in the bank for 1 year brings in R pounds

£1 in the bank for 1 year brings in $\frac{R}{100}$

£P in the bank for 1 year brings in $\frac{R}{100}\times P$ pounds.

£P in the bank for T years brings in

$$\frac{R}{100}\times P\times T \text{ pounds}=\frac{P\times R\times T}{100} \quad „$$

Call the interest I. Then $I=\frac{PRT}{100}$

That is, Interest $=\frac{\text{Principal}\times\text{Rate}\times\text{Time}}{100}$

What is the simple interest on £560 for 3 years at 5 per cent.?

$$\text{Interest} = \frac{\text{Principal} \times \text{Rate} \times \text{Time}}{100}$$

$$= £\frac{\overset{28}{\cancel{560}} \times \cancel{5} \times 3}{\underset{2}{\cancel{100}}}$$

$$= £84.$$

Now $I = \frac{P \times R \times T}{100}$ is an equation.

Multiply each side by 100 and

$$100 \times I = \frac{P \times R \times T \times 100}{100}$$

$$= P \times R \times T$$

or $\quad P \times R \times T = 100\ I.$

Divide each side by $P \times R$

Then $\quad \frac{\cancel{P} \times \cancel{R} \times T}{\cancel{P} \times \cancel{R}} = \frac{100\ I}{P \times R}$

or $\quad T = \frac{100\ I}{P \times R}$

That is, $\quad \text{Time} = \frac{100 \text{ times Interest}}{\text{Principal} \times \text{Rate}}$

Suppose we have the following problem: How long will £560 take to gain £84 simple interest at 5 per cent.?

$$T = \frac{100 \times I}{P \times R} \text{ years}$$

$$= \frac{\overset{2}{\cancel{100}} \times \overset{3}{\cancel{84}}}{\underset{28}{\cancel{560}} \times \cancel{5}} \text{ years}$$

$$= 3 \text{ years.}$$

Consider again the equation $I = \frac{PRT}{100}$.

Multiply each side by 100, then $100I = PRT$, or $PRT = 100I$.

Divide each side by PT.

Then $\quad \frac{\cancel{P}R\cancel{T}}{\cancel{P}\cancel{T}} = \frac{100I}{PT}$

or $\quad R = \frac{100I}{PT}$

That is, $\quad \text{Rate} = \frac{100 \text{ times Interest}}{\text{Principal} \times \text{Time}}.$

At what rate per cent. will £560 gain £84 in 3 years?

$$\text{Rate} = \frac{100 \times \text{Interest}}{\text{Principal} \times \text{Time}}$$

$$\frac{100 \times \overset{2}{\cancel{84}}}{\underset{2}{\cancel{560}} \times 3} = 5 \text{ per cent.}$$

At what rate per cent. will a sum of money double itself in 10 years?

Let x be the sum of money—that is, the principal P. Let R be the rate per cent. per annum, and T the time.

We must find R.

Now $I = \frac{PRT}{100}$

R $\frac{100I}{PT.}$ Note that the interest is the same as the principal, so $I = x$.

Hence $R = \frac{100I}{PT}$

$$= \frac{100\cancel{x}}{\cancel{x}T}$$

$\frac{100}{T}$. But $T = 10$ years

$$\frac{100}{10}$$

$$10.$$

$\therefore$ Rate is 10 per cent. per annum.

At what rate per cent. will £875, 2*s*. 6*d*. amount to £991, 16*s*. 2*d*. in 5 years?

If I put £100 in a bank that pays 4 per cent. per annum, I can go once a year to draw my £4 interest. But if I do not need the £4 I may let it lie in the bank. At the end of 1 year I have £104 in the bank, at the end of 2 years I have £108, after 3 years £112, and so on. So in 3 years £100 amounts to £112 if invested at 4 per cent. per annum. If I want to find what interest I possess, I subtract my principal, £100, from the total amount of principal plus interest, £112. So in the above problem I subtract £875, 2*s*. 6*d*. from £991, 16*s*. 2*d*. in order to find out how much interest I have on £875, 2*s*. 6*d* for 5 years. Hence I = £991, 16*s*. 2*d*. − £875, 2*s*. 6*d*., *i.e.* £116, 13*s*. 8*d*.

$$R = \frac{100I}{PT}$$

$$= \frac{100 \times £116,\ 13s.\ 8d.}{£875,\ 2s.\ 6d. \times 5}$$

Reduce to pence

$$= \frac{\overset{2}{\cancel{100}} \times \overset{4}{\cancel{28004}}}{\cancel{210030} \times \cancel{5}}$$

$$= 2\tfrac{2}{3} \text{ per cent.}$$

What sum of money will amount to £947, 10*s*. in 5 years at 5 per cent.?

A certain principal if placed in the bank for 5 years at 5 per cent. will amount to £947, 10*s*. Hence the interest is £947, 10*s*. minus the principal. Let P be the principal.

Then $\quad I = £947,\ 10s. - P$

Now $$I = \frac{PRT}{100}$$

$$P = \frac{100I}{RT}$$

$$= \frac{\overset{4}{\cancel{\overset{20}{\cancel{100}}}}(£947{\cdot}5 - P)}{\cancel{5} \times \cancel{5}}$$

$$= 4(947{\cdot}5 - P)$$

$$= 3790 - 4P. \quad \text{Transpose}$$

Then $$P + 4P = 3790$$
$$5P = 3790$$
$$P = £758.$$

Find the amount of £840 for 2 years 3 months at 4 per cent.

Amount = P + I. 2 years 3 months = $2\frac{1}{4}$ years.

Find the interest on £840 for $2\frac{1}{4}$ years at 4 per cent.

$$I = \frac{PRT}{100}$$

$$= \frac{840 \times 4 \times 2\frac{1}{4}}{100}$$

$$= \frac{840 \times 4x \times 2{\cdot}25}{100}$$

Multiply numerator and denominator by 100 so as to get rid of the decimal fraction

$$= \frac{\overset{42}{\cancel{840}} \times \cancel{4} \times \overset{9}{\cancel{\overset{45}{\cancel{225}}}}}{\underset{\underset{5}{\cancel{25}}}{\cancel{100}} \times \underset{\cancel{2}}{\cancel{100}}}$$

$$= \frac{42 \times 9}{5}$$

$$= \frac{378}{5}$$

$$= £75\tfrac{3}{5}$$

$$= £75,\ 12s.$$

Hence Interest is £75, 12*s.*

But amount = P + I

= £840 + £75, 12*s.*

= £915, 12*s.*

Find the simple interest on £325, 16*s.* 8*d.* lent for 3 years and 5 months at $4\frac{1}{2}$ per cent. simple interest. (L. C. lower, 1913.)

Reduce £325, 16*s.* 8*d.* to pence, or, better, to fourpences. Call 3 years 5 months 41 months or $\frac{41}{12}$ years. Call $4\frac{1}{2}$ per cent. 4·5 per cent.

Now $$I = \frac{PRT}{100}$$

$$= \frac{£325,\ 16s.\ 8d. \times 4\frac{1}{2} \times 3 \text{ yrs } 5 \text{ months}}{100}$$

$$= \frac{19530 \times 4{\cdot}5 \times \frac{41}{12}}{100} \text{ fourpences}$$

Multiply numerator and denominator by 12

$$= \frac{19530 \times 4{\cdot}5 \times \frac{41}{\cancel{12}} \times \frac{\cancel{12}}{1}}{100 \times 12} \text{ fourpences}$$

$$\frac{19530 \times 4{\cdot}5 \times 41}{100 \times 12} \text{ fourpences}$$

Multiply numerator and denominator by 10 to get rid of decimal fraction

$$= \frac{19530 \times 45 \times 41}{100 \times 12 \times 10} \text{ fourpences}$$

Divide by 3 to make fourpences shillings, and by 20 to make shillings pounds

$$= £\frac{\overset{391}{\cancel{19530}} \times \cancel{45} \times 41}{\underset{2}{\cancel{100}} \times \underset{4}{\cancel{12}} \times \underset{2}{\cancel{10}} \times \cancel{3} \times 20}$$

$$= £\frac{391 \times 41}{2 \times 4 \times 2 \times 20}$$

$$= £\frac{16031}{320}$$

$$= £50,\ 1s.\ 11\tfrac{1}{4}d.$$

The student should carefully study the following:

5 per cent. of £100 means £5 paid on every £100.

Now £5 is $\frac{5}{100}$ or $\frac{1}{20}$ of £100. So 5 men = $\frac{5}{100}$ or $\frac{1}{20}$ of 100 men. Thus 5 per cent. may be written as $\frac{5}{100}$ or $\frac{1}{20}$ or ·05.

The simple interest on £750 for 1 year at 5 per cent. is obviously ·05 or $\frac{5}{100}$ of £750.

$$\text{S.I.} = £750 \times {\cdot}05$$
$$= £37{\cdot}50$$
$$= £37,\ 10s.$$

Again, 4 per cent. $= \frac{4}{100} = {\cdot}04$. So 4 per cent. of £900 is £900 × ·04 or £36·00 or £36.

Also 3 per cent. $= \frac{3}{100} = {\cdot}03$

$$2\tfrac{1}{2} \text{ per cent.} = \frac{2\frac{1}{2}}{100} = \frac{2{\cdot}5}{100} = \frac{25}{1000} = {\cdot}025$$

$$7 \text{ per cent.} = \frac{7}{100} = {\cdot}07$$

$$8\tfrac{1}{2} \text{ per cent.} = \frac{8\frac{1}{2}}{100} = \frac{8{\cdot}5}{100} = \frac{85}{1000} \quad {\cdot}085$$

$$10 \text{ per cent.} = \frac{10}{100} = \frac{1}{10} = {\cdot}1.$$

We may solve simple interest problems by using these decimal fractions.

Find the simple interest on £750 for 4 years at 5 per cent.

5 per cent. = ·05.

S.I. on £750 for 1 year is £750 × ·05

" " 2 years is £750 × ·05 × 2

" " 3 years is £750 × ·05 × 3

" " 4 years is £750 × ·05 × 4

£750 × ·05 × 4 = £150

Hence Interest = £150

Find simple interest on £800 for 3 years 6 months at $2\frac{1}{2}$ per cent.

$$2\tfrac{1}{2} \text{ per cent.} = \frac{2\frac{1}{2}}{100} = \frac{2{\cdot}5}{100} = \frac{25}{1000} = {\cdot}025$$

Simple interest on £800 for 1 year is £800 × ·025.

Simple interest on £800 for $3\frac{1}{2}$ years is £800 × ·025 × $3\frac{1}{2}$ = £800 × ·025 × 3·5.

If we multiply ·025 by 1000 we get a whole number (25); if we multiply 3·5 by 10 we get a whole number (35).

Multiply £800 × ·025 × 3·5 by 1000 × 10 and divide by 1000 × 10 and its value remains unaltered. Thus

$$£800 \times {\cdot}025 \times 3{\cdot}5 = £\frac{800 \times {\cdot}025 \times 3{\cdot}5 \times 1000 \times 10}{1000 \times 10}$$

$$= £\frac{\overset{4}{\cancel{800}} \times \overset{5}{\cancel{25}} \times 35}{\underset{2}{\cancel{1000}} \times \underset{2}{\cancel{10}}}$$

$$= £70.$$

PRESENT WORTH AND DISCOUNT

Discount is a reduction made on a bill. Dr. Smythe wants a motor-car. He goes to the local agent and says: "I want a car, a four-seater. Ah! that's a beauty—how much for that one?" "Two-eighty pounds," replies the agent. "Well," says Dr. Smythe, "I am a new arrival in your town and as yet I have not made much money. Will you give me the car if I pay it in a year's time?" The doctor takes the car and agrees to pay £280 in a year's time. Now, from the agent's point of view this method is not entirely satisfactory; if Dr. Smythe paid for the car when he took it away the agent would have £280 to put into the bank or to invest in stocks; and if invested at 5 per cent. this £280 would bring in £14 in a year. If Mr. Whyte, the rich squire goes down to the motor agent to buy a car, say another £280 car, he can afford to pay on the spot. The motor agent says to himself: "I can invest this money and draw interest for it; that doctor fellow is really paying me £280 less the interest, or about £270. The squire is paying the full £280. I can easily allow him discount. I can allow him *6d.* off every pound—that will be 280 sixpences discount or £7." The squire pays £280 − £7 or £273 for his car. *6d.* in the pound is $2\frac{1}{2}$ per cent. discount. This kind of discount is known as TRADE DISCOUNT.

Dr. Smythe requires a garage, he requires a set of instruments and other necessaries. He decides to borrow some money from the squire. The squire says, "All right, doctor, I'll give you so much money, but you must pay interest at 5 per cent. In a year's time you can pay me £273." The sum the doctor has borrowed is £260, for in 1 year at 5 per cent., £260 will gain £13 interest, and the amount after 1 year will be £260 + £13 or £273. £260 is known as the PRESENT WORTH of £273 due 1 year hence at 5 per cent. simple interest. Suppose that after six months the doctor marries a rich wife. He goes to the squire saying, "I can pay that debt now, Mr. Whyte, instead of waiting until the end of the year." Now it would not be fair to make the doctor pay £273, for £273 is £260 plus the interest on £260 for 12 months at 5 per cent. The doctor has kept the money for 6 months only, *i.e.* he has paid the bill 6 months before it is due. Mr. Whyte says to himself: "I must find out what sum will amount to £273 in 6 months at 5 per cent., and I'll charge the doctor that." He finds that £266, *6s.* $9\frac{27}{41}$*d.* is the sum. The difference between this sum and £273 is called the TRUE DISCOUNT on £273. It will be seen that discount problems are really problems in simple interest.

Find the Present Worth and Discount of a bill for £616 due 2 years hence at 5 per cent. simple interest. The question may be written: What sum will amount to £616 in 2 years at 5 per cent.?

Let x be the sum.

$$I = \frac{PRT}{100}$$
$$= \frac{x \times 5 \times 2}{100}$$
$$= \frac{10x}{100} = \frac{x}{10}.$$

But principal + interest = amount

$$\therefore \qquad x + \frac{x}{10} = 616.$$

Multiply each side of the equation by 10.

Then
$$10x + x = 6160$$
$$11x = 6160$$
$$x = £560.$$

£560 will amount to £616 in 2 years at 5 per cent. Therefore £560 is the Present Worth of £616 due 2 years hence at 5 per cent. The True Discount is £616 − £560, or £56, because if the bill were paid now the amount to be paid would be only £560.

If £36 is the discount on a bill of £2436 due 6 months hence, what is the rate of interest?

Present Worth = Amount − Discount
= £2436 − £36
= £2400.

The problem now reads: At what rate per

cent. will £2400 gain £36 in 6 months (or ·5 of a year)?

$$I = \frac{PRT}{100}$$
$$R = \frac{100I}{PT}$$
$$= £\frac{100 \times 36}{2400 \times \cancel{\frac{6}{12}} \cdot 5}$$

Multiply numerator and denominator by 10 to make ·5 a whole number

$$= £\frac{\cancel{100} \times \overset{3}{\cancel{36}} \times \overset{2}{\cancel{10}}}{\underset{12}{\cancel{2400}} \times \cancel{5}}$$
$$= £3.$$

Rate is 3 per cent.

A bill for £508 is drawn on March 4th at 6 months, and is discounted on April 14th. Find the discount at 4 per cent.

According to law three days of grace are allowed. Suppose the squire lent money to the doctor and said: "You must pay me £460 a year hence; this is the 4th of May 1913, you must pay the money on or before May 4th, 1914." If the doctor knew anything about law he would reply: "Not May 4th but May 7th, 1914, for the law allows me three days of grace."

In the above problem £508 is to be paid six months after March 4th, that is, on September 4th; but as the debtor is allowed three days of grace, payment is not legally due until September 7th. Now the bill is discounted on April 17th—that is, the debtor goes to the creditor, saying: "I'll pay your money now. I am paying this bill 146 days before it is due. You must take off discount." The True Discount is found by answering the question: "What sum will amount to £508 in 146 days at 4 per cent?" (1 day $= \frac{1}{365}$ of a year; 146 days $= \frac{\overset{2}{\cancel{146}}}{\underset{5}{\cancel{365}}}$ of a year $= \frac{2}{5}$ of a year $= \cdot 4$ of a year.)

Let x be the sum.

$$I = \frac{PRT}{100}$$
$$= £\frac{x \times 4 \times \cdot 4}{100}$$
$$= £\frac{x \times \cancel{4} \times \overset{2}{\cancel{4}}}{\underset{25}{\cancel{100}} \times \underset{5}{\cancel{10}}}$$
$$= £\frac{2x}{125}$$

Amount = Principal + Interest

$$£508 = £x + £\frac{2x}{125}$$

Multiply each side by 125.

$$\text{Then}\quad \underset{4}{\cancel{508}} \times 125 = 125x + 2x$$
$$= \cancel{127}x. \quad \text{Cancel by 127}$$
$$4 \times 125 = x$$
$$x = £500.$$

The debtor pays £500 instead of £508. The True Discount is £508 − £500 = £8.

Bankers' Discount.—If Dr. Smythe borrows some money from Mr. Whyte and agrees to pay £550 in six months, Mr. Whyte, if he is a business man, will draw up a BILL OF EXCHANGE. This document will take the following form:

YORK, 10*th May*, 1913.

To R. G. Smythe, M.D., York.

Six months after date pay to myself or order the sum of Five Hundred and Eighty Pounds for value received.

£580, 0*s*. 0*d*. JOHN WHYTE.

Mr. Whyte sends the Bill of Exchange to Dr. Smythe for his "acceptance." If the doctor agrees to it he writes across the bill: "Accepted, payable at the Lincoln and Yorkshire Commercial Bank, York.—R. G. SMYTHE." The doctor is said to "accept" the bill, and he returns it to Mr. Whyte. In six months' time from May 10th—that is, on November 13th (allowing three days of grace)—Mr. Whyte can go to the bank named, present his bill, and draw £580.

Suppose the squire goes off to Scotland for the shooting. He suddenly finds that he has no money with him. He searches his pockets and finds the Bill of Exchange. He says to himself: "This is due on November 13th, and this is only the 16th of August, and I can't draw it." However, he motors to Aberdeen, enters a bank, and says: "I have a Bill of Exchange due in York on November 13th; could you give me money for it?" The banker (or bill-broker) replies: "Oh yes, I'll discount it for you. This is August 16th, and the bill has yet to run to November 13th. Let me see—15 days in August, all September or 30 days, all October or 31 days, and 13 days in November, that makes 89 days. I'll pay you the £580 less the simple interest on £580 for the 89 days it has yet to run." The BANKERS' DISCOUNT is not the True Discount. The True Discount on £580 for 89 days is found by discovering the sum that will amount to £580 in 89 days, and then subtracting this sum from £580.

Find the difference between True and Bankers' Discount on £660 due 2 years hence at 5 per cent.

True Discount = Amount − Present Worth. The Present Worth is the sum that will amount to £660 in 2 years at 5 per cent.

Let x be the sum in pounds.

Then £660$-x$=Interest on £x for 2 years at 5 per cent.

$$=\frac{P\times R\times T}{100}$$

$$=\frac{x\times 2\times 5}{100}=\frac{x}{10}$$

£6600$-10x=x$
£6600$=11x$
∴ x=£600=Present Worth

True Discount =Amount−Present Worth
=£660−£600
=£60.

Bankers' Discount is the simple interest on £660 for 2 years at 5 per cent.

$$I=\frac{PRT}{100}$$

$$=\frac{66\cancel{0}\times\cancel{5}\times\cancel{2}}{\cancel{100}}$$

=£66=Bankers' Discount.

Hence Bankers' Discount−True Discount
=£66−£60
=£6.

Percentages and Profit and Loss.—I buy a horse for £100 and sell it for £95. I thus lose £5. I had £100 originally; I lost £5 on my transaction, hence my loss was 5 per cent. Profit and loss are always reckoned as profit and loss *per cent.* Thus, if I buy a cow for £20 and sell her for £16, what is my loss per cent.?

On £20 I lose £4
„ £100 „ £4×5, or £20.
My loss is 20 per cent.

Gain and loss are always reckoned on the Cost Price or Buying Price.

I buy a motor-car for £700 and sell it for £770. What do I gain or lose per cent?

Obviously I gain £70 or $\frac{70}{700}$, *i.e.* $\frac{1}{10}$ of the money I spent. Hence gain is 10 per cent.

A horse cost me £40. What shall I sell it for so as to gain $7\frac{1}{2}$ per cent.?

$$7\tfrac{1}{2}\text{ per cent.}=\frac{7\frac{1}{2}}{100}=\frac{15\text{ halves}}{200\text{ halves}}=\frac{15}{200}=\frac{3}{40}$$

I have to gain $\frac{3}{40}$ of the Cost Price (C.P.).

$$\frac{}{40}\text{ of £40}=\text{£1}$$

$$\frac{3}{40}\text{ of £40}=\text{£3}$$

Hence Selling Price (S.P.) = £40+£3=£43.

I sold a bicycle for £3 and thereby lost 15 per cent.? What did I pay for it?

Let £x be the C.P. 15 per cent. loss $\frac{15}{100}$ loss $\frac{3}{20}$ loss.

Loss is reckoned on the C.P.

Hence 15 per cent. of $x=\frac{3}{20}$ of x

$$=\frac{3}{20}\times x$$

$$=\frac{3x}{20}=\text{loss.}$$

C.P.=S.P.+loss

∴ $x=£3+\frac{3x}{20}$. Multiply each side by 20

Then $20x=£60+3x$. Transpose
$20x-3x=£60$
$17x=£60$
$x=£\frac{60}{17}$
=£3, 10*s.* $7\frac{1}{17}d$.

A man sold a cart for £9 and lost 10 per cent. What should he have sold it for to gain 12 per cent.?

Find the C.P.

C.P.=S.P. + loss
=£9+$\frac{1}{10}$ of C.P.

∴ C.P.−$\frac{1}{10}$ C.P.=£9. Multiply each side by 10
10 C.P.−1 C.P.=£90
9 C.P.=£90
C.P.=£10
Cost Price is £10.

12 per cent. gain is $\frac{12}{100}$ of the C.P. gain.

$\frac{12}{100}$ of C.P.= $\frac{12}{100}$ of £10

$$=£\frac{12}{\cancel{100}}\times\frac{\cancel{10}}{1}$$

$=£1\frac{2}{10}=£1\frac{2}{10}=$£1, 4*s.* 0*d.*

A gain of 12 per cent. on £10 is £1, 4*s.*, hence to have sold the cart at a profit of 12 per cent. the man should have sold it for £10+£1, 4*s.* or £11, 4*s.*

When the C.P. is unknown we may imagine it to be £100. Thus when a man sells a cart for £9 and thereby loses 10 per cent., we may imagine the C.P. to be £100.

He loses 10 per cent. ∴ S.P.=£100−£10
=£90.

The problem stands thus: When the C.P. is £100 the S.P. is £90. What will the C.P. be when the S.P. is £9?

An S.P. of £90 has a C.P. of £100
„ £1 „ „ £$\frac{100}{90}$
£9 „ $\frac{10\cancel{0}\times\cancel{9}}{\cancel{90}}$ or £10.

In all Profit and Loss problems find the Cost Price first.

A man buys 3 tons of sugar for £66, 13*s*. 4*d*. and sells it at $2\frac{1}{2}d$. per lb. What is his profit per cent.?

$$3 \text{ tons} = 3 \times 20 \text{ cwts.}$$
$$= 3 \times 20 \times 112 \text{ lbs.}$$
$$3 \text{ tons at } 2\tfrac{1}{2}d. \text{ per lb.} = 3 \times 20 \times 112 \times 2\tfrac{1}{2} \text{ pence}$$
$$= £\frac{\cancel{3} \times \cancel{20} \times \overset{28}{\cancel{112}} \times 2\frac{1}{2}}{\underset{4}{\cancel{12}} \times \cancel{20}}$$
$$= £28 \times 2\tfrac{1}{2}$$
$$= £70 = \text{S.P.}$$
$$\text{Profit} = \text{S.P.} - \text{C.P.}$$
$$= £70 - £66,\ 13s.\ 4d.$$
$$= £70 - £66\tfrac{2}{3}$$
$$= £3\tfrac{1}{3}.$$

On $£66\frac{2}{3}$ he gains $£3\frac{1}{3}$

$$\text{,, } £1 \quad \text{,, } \quad \frac{3\frac{1}{3}}{66\frac{2}{3}}$$

$$\text{,, } £100 \quad \text{,, } \quad \frac{3\frac{1}{3} \times 100}{66\frac{2}{3}}$$
$$= 3\tfrac{1}{3} \times 100 \div 66\tfrac{2}{3}$$
$$= \frac{\overset{5}{\cancel{10}}}{\cancel{3}} \times \frac{\cancel{100}}{1} \times \frac{\cancel{3}}{\underset{2}{\cancel{200}}} = 5$$

The man gains 5 per cent.

Find the cost of an article when 3*s*. represents the difference between selling it at a gain of 10 per cent. and a loss of $12\frac{1}{2}$ per cent.

Let £x be the C.P.

$$10 \text{ per cent.} = \frac{10}{100} = \frac{1}{10}$$
$$12\tfrac{1}{2} \quad \text{,,} \quad = \frac{12\frac{1}{2}}{100} = \frac{12\cdot5}{100} = \frac{125}{1000} = \frac{1}{8}$$
$$x + \tfrac{1}{10} \text{ of } x = \text{1st S.P.}$$
$$x - \tfrac{1}{8} \text{ of } x = \text{2nd S.P.}$$

$$\text{Then} \quad \left(x + \frac{x}{10}\right) - \left(x - \frac{x}{8}\right) = 3$$
$$\cancel{x} + \frac{x}{10} - \cancel{x} + \frac{x}{8} = 3$$
$$\frac{x}{10} + \frac{x}{8} = 3$$

Multiply each side by 40.

$$\frac{40x}{10} + \frac{40x}{8} = 3 \times 40$$
$$4x + 5x = 120$$
$$9x = 120$$
$$x = \frac{\overset{40}{\cancel{120}}}{\underset{3}{\cancel{9}}}$$

$$\text{Hence C.P.} = \frac{40}{3} \text{ shillings}$$
$$= 13/4.$$

How much per cent. is gained by buying apples at 2 a penny and selling them at 3 for 2*d*.?

$$\text{C.P.} = 2 \text{ for } 1d. = 6 \text{ for } 3d.$$
$$\text{S.P.} = 3 \text{ for } 2d. = 6 \text{ for } 4d.$$
$$\therefore \quad 1d. \text{ is gained on } 3d. \text{ (the C.P.)}$$
$$\therefore \quad \text{gain per}\tfrac{100}{3} = 33\tfrac{1}{3}$$

The selling price of an article is to the cost price as the ratio 5 : 3. Find the gain per cent.

If C.P. is, say, £3
S.P. ,, £5
$\therefore$ gain is £2.

The C.P. £3 gains £2
$\therefore$ £1 ,, $£\frac{2}{3}$
$\therefore$ £100 ,, $£\frac{2}{3} \times 100$ or $\frac{200}{3}$ or $£66\frac{2}{3}$.

Hence gain is $66\frac{2}{3}$ per cent.

Compound Interest.—If I put £100 in a bank that pays 5 per cent. per annum, at the end of a year I could draw £5 interest. But if I do not require the £5 my capital or principal is now £105, and at the end of the second year I shall have interest not on £100, but on £105, *i.e.* £5, 5*s*. If I leave this in the bank my principal is now £105 + £5, 5*s*. or £110, 5*s*. At the end of the third year I shall receive interest on £110, 5*s*., and so on. When the simple interest is added to the principal each year money is said to be invested at COMPOUND INTEREST. This is the system obtaining in the Post Office Savings Bank, but not in the ordinary bank. Let us find the amount of £450 for 3 years at 5 per cent. compound interest.

$$5 \text{ per cent.} = \frac{5}{100} = \cdot05.$$

S.I. on £450 for 1 year at 5 per cent. is £450 × ·05 or £22·5.

Principal at beginning of 2nd year is £450 + £22·5 or £472·5.

S.I. on £472·5 for 1 year at 5 per cent is £472·5 × ·05 or £23·625.

Principal at beginning of 3rd year is £472·5 + £23·625 or £496·125.

S.I. on £496·125 for 1 year at 5 per cent. is £496·125 × ·05 or £24·80625.

Hence Compound Interest on £450 for 3 years = £24·80625.

Amount at end of 3rd year is £496·125 + £24·80625 or £520·93125 or £520, 18*s*. $7\frac{1}{2}$d.

The above should be arranged thus:

	£
Principal for 1st year	450
Interest ,, ,, ...	22·5
Amount at end of 1st year or principal for 2nd year	472·5
Interest for 2nd year	23·625
Amount at end of 2nd year or principal for 3rd year	496·125
Interest for 3rd year	24·80625
Amount for 3 years	520·93125

= £520, 18*s*. $7\frac{1}{2}d$.

Let us try to find a general formula for the solution of compound interest problems.

If £540 is invested for 5 years at 4 per cent. compound interest, we find the interest on £540 for 1 year is £540 ×·04 and then we add this interest to £540 to make our new principal.

Add £540·04 to £540 and you have (£540 ×·04) + £540.

540 is a common factor, hence (£540 + ·04) + £540 = £540(·04 + 1) = £540(1·04) = £540 × 1·04.

The principal for 2nd year is £540 × 1·04, and this is obviously the amount for 1 year.

The amount for 2 years is £540 × 1·04 × 1·04 or £540 × $(1{\cdot}04)^2$.

The amount for 3 years is £540 × 1·04 × 1·04 × 1·04 or £540 × $(1{\cdot}04)^3$.

The amount for 4 years is £540 × 1·04 × 1·04 × 1·04 × 1·04 or £540 × $(1{\cdot}04)^4$.

Hence

$$\text{Amount} = \text{Principal} \times \left(1 + \frac{\text{rate per cent.}}{100}\right)^n$$

where n is the number of years.

Suppose we have to find the amount of £450 for 3 years at 5 per cent. compound interest.

$$\text{Amount} = £450 \times \left(1 + \frac{5}{100}\right)^3$$

$$= £450 \times \left(\frac{105}{100}\right)^3$$

$$= £450 \times \frac{105}{100} \times \frac{105}{100} \times \frac{105}{100}$$

$$= £\frac{\overset{9}{\cancel{450}} \times \overset{21}{\cancel{105}} \times \overset{21}{\cancel{105}} \times \overset{21}{\cancel{105}}}{\underset{2}{\cancel{100}} \times \underset{20}{\cancel{100}} \times \underset{\underset{4}{\cancel{20}}}{\cancel{100}}}$$

$$= £\frac{9 \times 21 \times 21 \times 21}{2 \times 20 \times 4}$$

$$= £\frac{83349}{160}$$

$$= £520,\ 18s.\ 7\tfrac{1}{2}d.$$

What principal will amount to £424, 9*s*. 3*d*. in 3 years at 5 per cent. compound interest?

$$P \times \left(1 + \frac{\text{rate per cent.}}{100}\right)^n = \text{Amount}.$$

Divide each side of the equation by

$$\left(1 + \frac{\text{rate per cent.}}{100}\right)^n$$

$$P = \frac{\text{Amount}}{\left(1 + \frac{\text{rate per cent.}}{100}\right)^n}$$

$$= £\frac{424,\ 9s.\ 3d.}{\left(1 + \frac{5}{100}\right)^3}$$

$$= \frac{101871}{\left(1 + \frac{5}{100}\right)^3} \text{ pence}$$

$$= 101871 \div \left(1 + \frac{5}{100}\right)^3 \text{ pence}$$

$$= 101871 \div \left(\frac{105}{100}\right)^3 \text{ pence}$$

$$= 101871 \div \left(\frac{105}{100} \times \frac{105}{100} \times \frac{105}{100}\right) \text{ pence}$$

$$= \underset{\underset{\underset{11}{\cancel{231}}}{\cancel{4851}}}{101871} \times \frac{\overset{20}{\cancel{100}}}{\underset{21}{\cancel{105}}} \times \frac{\overset{20}{\cancel{100}}}{\underset{21}{\cancel{105}}} \times \frac{\overset{20}{\cancel{100}}}{\underset{21}{\cancel{105}}} \text{ pence}$$

$$= \frac{\cancel{101871} \times 20 \times 20 \times 20}{\underset{7}{\cancel{21}} \times \underset{7}{\cancel{21}} \times \underset{7}{\cancel{21}}} \text{ pence}$$

$$= 11 \times 20 \times 20 \times 20 \text{ pence}$$

$$= £\frac{11 \times \overset{5}{\cancel{20}} \times 20 \times \cancel{20}}{\underset{3}{\cancel{12}} \times \cancel{20}}$$

$$= £\frac{1100}{3} = £366,\ 13s.\ 4d.$$

STOCKS AND SHARES.

If I decide to start in business as a motor-car manufacturer, I require money to buy the workshop and tools, to pay rent and taxes, to pay workmen, &c. The money necessary to start business is known as CAPITAL. One man may have enough capital to set up a motor-car factory, but in big undertakings such as the making of a railway capital comes not from one man or two men, but from many people. These people form what is called a COMPANY, and each member of the Company is known as a SHAREHOLDER because he has a *share* or shares in the capital. Let us suppose that John Smith, a wealthy manufacturer, has a plan for building a great theatre. He mentions the idea to his friends, Brown and Murray. Murray cries: "Good idea! let's float a company." They advertise the fact that a new theatre is to be built at a cost of £10,000, and offer to sell a hundred £100 shares. Jones comes along and says: "I want 4 shares" and he pays his £400. Jones is said to invest his money in the Shakespeare Theatre Co. (let us call it). When the theatre is built the profits go to the people who have shares in the company. The profit of the first year is £2000. This profit is *divided* amongst the shareholders, and is known as the DIVIDEND. There are 100 shares, hence the holder of each share will get £2000 ÷ 100 or £20. Jones has 4 shares: he gets £80 a year for the £400 he invested. Evidently this is a thriving company; it is paying a 20 per cent. dividend. Now Jones cannot withdraw his money from the company,

for it was used to pay masons, joiners, &c. But he can sell his share or shares. He paid £100 for each share; £100 is said to be the share's NOMINAL VALUE. If I go to Jones and say: "I say, Mr. Jones, you paid £100 for each share in that Theatre Company, will you sell me your 4 shares at £100 each?" Jones replies: "My dear sir, do you imagine I am a fool? Do you think I'm going to sell you a £100 share that is bringing me in £20 a year? If you want to buy my shares, you must pay a good deal more than £100 for a £100 share."

Gradually the profits of the theatre grow less; a cinema house has been opened on the other side of the street and is attracting most of the people who want amusement. A time comes when the profits have vanished, and poor Jones does not get a single penny of dividend. I go to Jones again and say: "Well, are you going to sell me your four £100 shares?" Jones eagerly answers: "Yes, most certainly I will. Look here, I'll give you them at the figure I bought them at—£100 a share." I laugh: "My dear Mr. Jones," I say, "the company is paying no dividend. Do you think I am stupid enough to pay £100 for a share that brings me no dividend. I will give you £90 for each share." Jones agrees and I pay him £360 for his 4 shares. Why do I buy shares that are of no value? I have a plan. I want to become a shareholder in the company and then I mean to propose to the directors—the shareholders appointed to manage the expenditure of the capital—that the theatre be turned into a music-hall. I know that the public will rush to see acrobats while they will go to sleep if Ibsen or Shakespeare is being played. My plan is adopted and I grow rich; so do the other shareholders who had not the initiative to foresee that music-hall sketches would bring profits. Many men are rich because they bought shares when they were cheap and sold them when they were valuable. Buying a share when it is at its nominal value is known as buying at *Par;* buying a share when it is worth less than its nominal value is buying at a *Discount;* buying at more than its nominal value is buying at a *Premium.* When any portion of a company's capital may be bought or sold the capital is called *stock.* Stock is generally reckoned in hundreds of pounds. The theatre company shares were originally bought for £100, and we may call each share £100 stock. If Jones can sell his shares for £104 each, the company is evidently making profit; if he can get only £86 for his £100 stock the cinema house over the way is evidently taking all the custom. Suppose our theatre company is paying a dividend of 4 per cent. on its stock and its £100 stock is selling for £105 we denote these facts by the expression 4 per cent. stock at 105.

My imaginary conversation with the imaginary Mr. Jones would hardly take place in real life, for Jones does not sell his own stock. Stocks are bought and sold through a dealer, who is known as a stockbroker. Naturally the stockbroker is not a philanthropist: he charges a commission on each transaction. This commission is known as "brokerage," and its amount is $\frac{1}{8}$ per cent—that is, $£\frac{1}{8}$ on every £100 stock. If I *buy* £100 stock for £102, I have to pay $£102\frac{1}{8}$ to the broker for each £100 stock. If I *sell* £100 stock for £102, I only receive £102 minus the brokerage, *i.e.* $£102-£\frac{1}{8}$, or $£101\frac{7}{8}$.

The British Government often borrows money from private persons; for instance, during the Boer War millions of pounds were borrowed. The money borrowed by the Government is known as the National Debt. Every £100 originally lent is considered as £100 stock, and Government stock is called "Funds" or "Consols" (*i.e.* Consolidated Annuities). The National Debt (1913) was £724,463,625. The dividend paid on Consols is $2\frac{1}{2}$ or $2\frac{3}{4}$ per cent.

Examples.—What is the cash value of £1600 stock at 84?

I have £1600 stock. I sell each £100 stock for 84. What cash will I receive for £1600 stock?

£100 stock brings me £84.

£1600 „ „ £84 × 16, or £1344.

I have £7800 stock in Brazilian 4 per cents. at 108. What do I receive if I sell out?

If I sell £100 stock I receive £108.

If I sell £7800 stock I receive £108 × 78, or £8424.

How much money must be spent in purchasing 3 per cent. consols at 93 to produce an income of £270?

£93 buys £100 stock; but £100 stock yields a dividend of £3, hence for every £93 I invest I receive £3 income.

£3 income is produced by £93.

£1 „ „ „ $£\frac{93}{3}$.

£270 „ „ $£93\times\frac{\cancel{270}^{90}}{\cancel{3}}$ or £8370.

By how much do I increase my income if I sell £3150 out of the 4 per cents. at par, and invest the money in the 5 per cents. at 105?

I have £3150 stock. I sell it at par, *i.e.* I sell each £100 stock for £100. Hence for £3150 stock I receive £3150 cash. I invest this cash in the 5 per cents. at 105—that is, I go to a company whose £100 shares are selling at £105.

With £105 I buy £100 stock

„ £1 „ $£\frac{100}{105}$ „

„ £3150 „ $100\times\frac{\cancel{3150}^{30}}{\cancel{105}}$, or £3000 stock.

Now before I sold out I had £3150 stock at 4 per cent.

Each £100 stock brought me £4 income.

Therefore £1 stock brought me £$\frac{4}{100}$ income.

Hence £3150 brought me £$\frac{\overset{2}{\cancel{4}}}{\underset{\cancel{2}}{\cancel{100}}}\times\overset{63}{\cancel{3150}}$, or £126 income.

Afterwards I had £3000 stock at 5 per cent.

£100 stock brought me £5 income.

£3000 „ „ £5 $\times$ 30 income, or £150.

The difference between my first and second incomes was £150 $-$ £126, or £24.

I therefore increased my income by £24.

My annual income from 3 per cent. consols, which stand at 10 below par, is £1500. What amount have I invested in them?

These consols if sold at par would bring £100 cash for each £100 stock; at 10 below par they bring only £90 cash for £100 stock.

Thus I receive £3 income by investing £90; I receive £1 income by investing £30; I receive £1500 income by investing £30 $\times$ 1500, or £45,000.

Answer, £45,000.

I sell £4000 stock and receive £3655 for it. At what price did I sell? (Brokerage $\frac{1}{8}$.)

The broker charged me £$\frac{1}{8}$ for every £100 stock he sold, hence his brokerage for selling £4000 was 40 times £$\frac{1}{8}$ or £$\frac{40}{8}$ or £5. He sold the stock for a certain sum; he pocketed £5 and handed the rest (£3655) to me. What he really received from the buyer was £3655 + £5, or £3660.

Thus my £4000 stock sold for £3660

$\therefore$ £100 „ „ £$\frac{3660}{40}$, or £$91\frac{1}{2}$.

I sold at $91\frac{1}{2}$.

Which is the better stock, the $4\frac{1}{2}$ at $92\frac{1}{2}$ or the $5\frac{1}{4}$ at 105?

If I buy £100 stock for £$92\frac{1}{2}$ I receive an income of £$4\frac{1}{2}$. If I buy £100 stock for £105 I receive an income of £$5\frac{1}{4}$.

In the first case £$4\frac{1}{2}$ is obtained by investing £$92\frac{1}{2}$.

$\therefore$ £1 is obtained by investing £$\frac{92\frac{1}{2}}{4\frac{1}{2}}$,

or £$\frac{185}{9}$, *i.e.* £$20\frac{5}{9}$.

In the second case £$5\frac{1}{4}$ is obtained by investing £105.

$\therefore$ £1 is obtained by investing £$\frac{105}{5\frac{1}{4}}$,

or £$\frac{420}{21}$, *i.e.* £20.

The latter is the better stock, since £20 yields the same amount (viz. £1) as £$20\frac{5}{9}$ of the former.

A neater way is to invest £$92\frac{1}{2}\times 105$ in each.

By investing £$92\frac{1}{2}$ I get income of £$4\frac{1}{2}$.

„ „ £$92\frac{1}{2}\times 105$ I get income of £$4\frac{1}{2}\times 105$ or £$472\frac{1}{2}$.

Again, by investing £105 I get income of £$5\frac{1}{4}$.

„ „ £$92\frac{1}{2}\times 105$ I get income of £$5\frac{1}{4}\times 92\frac{1}{2}$ or £$485\frac{5}{8}$.

Hence the $5\frac{1}{4}$ stock at 105 is the better investment.

Students must distinguish between STOCK and CASH. Income comes from STOCK, not CASH.

Find my income if I have £1200 of 3 per cent. stock at £$106\frac{1}{8}$.

I have £1200 STOCK; each £100 stock brings me £3 income, $\therefore$ £1200 brings me £12 $\times$ 3 or £36 income.

Find my income if I invest £700 in the 4 per cents. at 102.

This £700 is *cash*, not stock. You must find how much stock it will buy.

£102 cash buys £100 stock

£1 „ „ £$\frac{100}{102}$ „

£700 „ „ £$\frac{100\times\overset{350}{\cancel{700}}}{\underset{51}{\cancel{102}}}$ = £$\frac{35,000}{51}$.

Now each £100 stock yields an income of £4.

$\therefore$ £1 stock yields an income of £$\frac{4}{100}$.

$\therefore \frac{35,000}{51}$ stock yields an income of £$\frac{4}{1\cancel{00}}\times$ £$\frac{35,0\cancel{00}}{51}$, or £$\frac{1400}{51}$, *i.e.* £27, $9\frac{1}{51}s$.

INDICES.

We have seen that $a^6\times a^4=a^{6+4}=a^{10}$
and that $a^6\div a^4=a^{6-4}=a^2$.

Hence $a^m\times a^n=a^{m+n}$

and $a^m\div a^n$ or $\frac{a^m}{a^n}=a^{m-n}$.

Suppose we have an index in the form of a fraction—say $\frac{1}{2}$. a^2 means a squared; what does $a^{\frac{1}{2}}$ mean? Let us multiply $a^{\frac{1}{2}}$ by $a^{\frac{1}{2}}$:

Then $a^{\frac{1}{2}}\times a^{\frac{1}{2}}=a^{\frac{1}{2}+\frac{1}{2}}=a^1$

Hence $a^{\frac{1}{2}}$ is an expression which, multiplied by itself, *i.e.* squared, gives a. $\therefore (a^{\frac{1}{2}})^2=a$.

Take square root of each side and $a^{\frac{1}{2}}=\sqrt{a}$.

In the same way $a^{\frac{1}{3}}=\sqrt[3]{a}$, $a^{\frac{1}{4}}=\sqrt[4]{a}$, $a^{\frac{1}{s}}=\sqrt[s]{a}$, *i.e.* the s^{th} root of a.

What do we mean by $a^{\frac{2}{3}}$?

$$a^{\frac23}\times a^{\frac23}\times a^{\frac23} = a^{\frac23+\frac23+\frac23} = a^{\frac63} = a^2,$$

that is $(a^{\frac23})^3 = a^2$; take the cube root of each side and $a^{\frac23} = \sqrt[3]{a^2}$.

To find the meaning of $a^{\frac{s}{k}}$ where s and k are positive integers:

$$a^{\frac sk}\times a^{\frac sk} = a^{\frac sk+\frac sk} = a^{\frac{2s}{k}}$$

$$a^{\frac sk}\times a^{\frac sk}\times a^{\frac sk} = a^{\frac sk+\frac sk+\frac sk} = a^{\frac{3s}{k}}$$

$$a^{\frac sk}\times a^{\frac sk}\times a^{\frac sk}\ \ldots \text{ to } k \text{ factors} = a^{\frac{ks}{k}}$$
$$= a^s,$$

i.e. $a^{\frac sk}$ multiplied by itself k times $= a^s$,

or $\left(a^{\frac sk}\right)^k = a^s$. Take the k^{th} root of each side,

and $a^{\frac sk} = \sqrt[k]{a^s}$.

Find the meaning of a^0.

$a^m\times a^n = a^{m+n}$ is true for all values of m and n.

If $m = 0$

$a^m = a^0$

and $a^0\times a^n = a^{0+n}$

$= a^n$. Divide each side by a^n,

and $a^0 = \dfrac{a^n}{a^n}$

$= 1$.

Find the meaning of x^{-2}.

Multiply x^2 by x^{-2}. $x^2 \times x^{-2} = x^{2+(-2)} = x^{2-2} = x^0 = 1$.

$$\therefore\ x^{-2} = \frac{1}{x^2} = \text{the reciprocal of } x^2.$$

Find the meaning of a^{-n}. Multiply it by a^n, then $a^{-n}\times a^n = a^{-n+n} = a^0 = 1$.

Divide each side by a^n,

and $$a^{-n} = \frac{1}{a^n}.$$

Prove that $a^m \div a^n = a^{m-n}$.

$$a^m \div a^n = a^m \times \frac{1}{a^n}$$
$$= a^m \times a^{-n}$$
$$= a^{m-n}.$$

Prove that $(a^m)^n = a^{mn}$.

$a^m\times a^m\times a^m = a^{m+m+m} = a^{3m}$,
$a^m\times a^m$ to n factors $= a^{nm} = a^{mn}$.

Prove $a^n\times b^n\times c^n = (abc)^n$.

$(abc)^n = (a\times a\times a\ \ldots$ to n factors$)\times(b\times b\times b\ \ldots$ to n factors$)\times(c\times c\times c\ \ldots$ to n factors$)$
$= a^n\times b^n\times c^n = a^nb^nc^n = (abc)^n$.

Find the value of $(ab)^n$ where n is negative.

Let $n = -k$, then $(ab)^n = (ab)^{-k}$

$$= \frac{1}{(ab)^k}$$
$$= a^{-k}b^{-k}$$
$$= a^nb^n.$$

Let us return to the study of descending powers of x. We already know that x^4, x^3, x^2, x are descending powers of x. Let us call x, x^1. Descending powers of x are . . .

x^5, x^4, x^3, x^2, x^1, x^0, x^{-1}, x^{-2}, x^{-3}, x^{-4}, x^{-5}, &c.,

or x^5, x^4, x^3, x^2, x, 1, $\frac1x$, $\frac1{x^2}$, $\frac1{x^3}$, $\frac1{x^4}$, $\frac1{x^5}$, &c.

Exercises.—Simplify $\left(\dfrac{16x^2}{y^{-2}}\right)^{-\frac14}$

$$\left(\frac{16x^2}{y^{-2}}\right)^{-\frac14} = \left(\frac{16x^2}{\frac{1}{y^2}}\right)^{-\frac14}$$
$$= \left(16x^2\times\frac{y^2}{1}\right)^{-\frac14}$$
$$= (16x^2y^2)^{-\frac14}$$
$$= \frac{1}{(16x^2y^2)^{\frac14}}$$
$$= \frac{1}{\sqrt[4]{16x^2y^2}}$$
$$= \frac{1}{\sqrt[4]{16}\times\sqrt[4]{x^2}\times\sqrt[4]{y^2}}$$
$$= \frac{1}{2x^{\frac24}y^{\frac24}}$$
$$= \frac{1}{2x^{\frac12}y^{\frac12}}$$

Simplify $x^{\frac23}\times x^{-\frac32}$.

$$x^{\frac23}\times x^{-\frac32} = x^{\frac23+(-\frac32)}$$
$$= x^{\frac23-\frac32}$$
$$= x^{\frac46-\frac96}$$
$$= x^{-\frac56}.$$

Simplify $\sqrt[3]{ab^{-1}c^{-2}}\times(a^{-1}b^{-2}c^{-4})^{-\frac16}$, making direct use of the rules.

Expression

$$= \left(ab^{-1}c^{-2}\right)^{\frac13}\times\left(a^{-1}b^{-2}c^{-4}\right)^{-\frac16}$$
$$= a^{\frac13}b^{-\frac13}c^{-\frac23}\times a^{+\frac16}b^{+\frac26}c^{+\frac46}$$
$$= a^{\frac13+\frac16}\times b^{-\frac13+\frac26}\times c^{-\frac23+\frac46}$$
$$= a^{\frac12}\times b^0\times c^0$$
$$= a^{\frac12}.$$

Multiply $a^{\frac{4}{3}}-2+a^{-\frac{4}{3}}$ by $a^{\frac{2}{3}}-a^{-\frac{2}{3}}$.

$$\begin{array}{l}
\quad a^{\frac{4}{3}}-2+a^{-\frac{4}{3}} \\
\quad a^{\frac{2}{3}}-a^{-\frac{2}{3}} \\
\hline
a^{\frac{4}{3}+\frac{2}{3}}-2a^{\frac{2}{3}}+a^{-\frac{4}{3}+\frac{2}{3}} \\
\qquad -a^{\frac{4}{3}-\frac{2}{3}}+2a^{-\frac{2}{3}}-a^{-\frac{4}{3}-\frac{2}{3}} \\
\hline
a^{2}-3a^{\frac{2}{3}}+3a^{-\frac{2}{3}}-a^{-2}.
\end{array}$$

Divide $8x^{-n}-8x^{n}+5x^{3n}-3x^{-3n}$ by $5x^{n}-3x^{-n}$.

Arrange in descending powers of x.

$$\begin{array}{l}
5x^{n}-3x^{-n}\ )\ 5x^{3n}-8x^{n}+8x^{-n}-3x^{-3n}(x^{2n}-1+x^{-2n} \\
\qquad\qquad\quad 5x^{3n}-3x^{n} \\
\qquad\qquad\qquad -5x^{n}-8x^{-n} \\
\qquad\qquad\qquad -5x^{n}-3x^{-n} \\
\qquad\qquad\qquad\qquad +5x^{-n}+3x^{-3n} \\
\qquad\qquad\qquad\qquad \underline{+5x^{-n}+3x^{-3n}}
\end{array}$$

Find the square root of $4x^{\frac{3}{2}}-12x^{\frac{3}{4}}+25-24x^{-\frac{3}{4}}+16x^{-\frac{3}{2}}$.

$$\begin{array}{lll}
2x^{\frac{3}{4}} & \sqrt{4x^{\frac{3}{2}}-12x^{\frac{3}{4}}+25-24x^{-\frac{3}{4}}+16x^{-\frac{3}{2}}} & \Big(\, 2x^{\frac{3}{4}}-3 \\
 & \underline{4x^{\frac{3}{2}}} & \quad +4x^{-\frac{3}{4}} \\
4x^{\frac{3}{4}}-3 & \quad -12x^{\frac{3}{4}}+25 & \\
 & \quad \underline{-12x^{\frac{3}{4}}+\ 9} & \\
 & \qquad\qquad 16-24x^{-\frac{3}{4}}+16x^{-\frac{3}{2}} & \\
4x^{\frac{3}{4}}-6+4x^{-\frac{3}{4}} & \qquad\qquad \underline{16-24x^{-\frac{3}{4}}+16x^{-\frac{3}{2}}} &
\end{array}$$

$$\text{Square root} = 2x^{\frac{3}{4}}-3+4x^{-\frac{3}{4}}.$$

These exercises require much thought. To find the square root of $4x^{\frac{3}{2}}$ we ask what term multiplied by itself will give $4x^{\frac{3}{2}}$. $2 \times 2 = 4$. Now $x^{\frac{3}{2}} = x^{k} \times x^{k}$, where $k = \frac{1}{2}$ of $\frac{3}{2}$.

$$= x^{\frac{3}{4}} \times x^{\frac{3}{4}}. \quad \text{Hence } \sqrt{4x^{\frac{3}{2}}} = 2x^{\frac{3}{4}}.$$

Again, in the last part, we divide 16 by $4x^{\frac{3}{4}}$.

Now $$\frac{16}{4x^{\frac{3}{4}}} = \frac{4}{x^{\frac{3}{4}}} = 4x^{-\frac{3}{4}}$$

Hence $$\begin{aligned} 4x^{\frac{3}{4}} \times 4x^{-\frac{3}{4}} &= 16x^{0} \\ &= 16 \times 1 \\ &= 16. \end{aligned}$$

SURDS

A surd is an irrational quantity, *i.e.* a quantity whose roots cannot be exactly obtained. Examples of surds are $\sqrt{3}$, $\sqrt[3]{7}$, $\sqrt[4]{9}$, $\sqrt[3]{4}$, and so on. In algebra $\sqrt{a}$ is a surd, so also $\sqrt{a^2+ad+b^2}$. But $\sqrt{a^2+2ab+b^2}$ is not a surd, for the square root of $a^2+2ab+b^2$ can be found exactly.

Still we may for convenience write a rational quantity as a surd. For instance, 4 may be written $\sqrt{16}$, x may be written $\sqrt{x^2}$ or $\sqrt[3]{x^3}$, or $\sqrt[k]{x^k}$ (*i.e.* the k^{th} root of x^k).

A surd of one order may be transformed into a surd of another order, *e.g.*

$$\sqrt[3]{5} = 5^{\frac{1}{3}} = 5^{\frac{2}{6}} = \sqrt[6]{5^2}$$

$$\sqrt[k]{a} = a^{\frac{1}{k}} = a^{\frac{s}{sk}} = \sqrt[sk]{a^s}.$$

Surds of different orders may be transformed into surds of the same order. Take $\sqrt{a}$ and $\sqrt[3]{b^2}$.

$$\sqrt{a} = a^{\frac{1}{2}} = a^{\frac{3}{6}} = \sqrt[6]{a^3}$$

$$\sqrt[3]{b^2} = b^{\frac{2}{3}} = b^{\frac{4}{6}} = \sqrt[6]{b^4}$$

Which is the greater, $\sqrt{5}$ or $\sqrt[3]{10}$?

$$\sqrt{5} = 5^{\frac{1}{2}} = 5^{\frac{3}{6}} = \sqrt[6]{5^3} = \sqrt[6]{125}$$

$$\sqrt[3]{10} = 10^{\frac{1}{3}} = 10^{\frac{2}{6}} = \sqrt[6]{10^2} = \sqrt[6]{100}$$

$\therefore \sqrt{5}$ is the greater, since 125 is greater than 100.

Express as surds of the same lowest order $\sqrt[8]{x^3}$, $\sqrt[9]{x^6}$, $\sqrt[20]{x^5}$.

$$\sqrt[8]{x^3} = x^{\frac{3}{8}} \qquad = x^{\frac{9}{24}} = \sqrt[24]{x^9}$$

$$\sqrt[9]{x^6} = x^{\frac{6}{9}} = x^{\frac{2}{3}} = x^{\frac{16}{24}} = \sqrt[24]{x^{16}}$$

$$\sqrt[20]{x^5} = x^{\frac{5}{20}} = x^{\frac{1}{4}} = x^{\frac{6}{24}} = \sqrt[24]{x^6}$$

We saw that a rational quantity can be written in surd form. Thus $6 = \sqrt{36} = \sqrt[3]{6^3}$. Hence we may write 4 times $\sqrt{2}$ as $4\sqrt{2}$ or $\sqrt{16}$ times $\sqrt{2}$, *i.e.* $\sqrt{16} \times \sqrt{2} = \sqrt{16 \times 2} = \sqrt{32}$. Conversely $\sqrt{32} = \sqrt{16 \times 2} = \sqrt{16} \times \sqrt{2} = 4\sqrt{2}$. The surd $\sqrt{32}$ is said to be reduced to its simplest form when it is written $4\sqrt{2}$.

Express $\sqrt{147}$ and $\sqrt{27a^3b^5}$ in their simplest forms.

$$\sqrt{147} = \sqrt{49 \times 3} = \sqrt{49} \times \sqrt{3} = 7\sqrt{3}.$$

$$\begin{aligned}
\sqrt{27a^3b^5} &= \sqrt{27a^3} \times \sqrt{b^5} \\
&= \sqrt{9 \times 3 \times a^2 \times a} \times \sqrt{b^2 \times b^2 \times b} \\
&= \sqrt{9} \times \sqrt{3} \times \sqrt{a^2} \times \sqrt{a} \times \sqrt{b^2} \times \sqrt{b^2} \\
&\qquad \times \sqrt{b} \\
&= 3 \times \sqrt{3} \times a \times \sqrt{a} \times b \times b \times \sqrt{b} \\
&= 3ab^2 \times \sqrt{3} \times \sqrt{a} \times \sqrt{b} \\
&= 3ab^2\sqrt{3 \times a \times b} \\
&= 3ab^2\sqrt{3ab}.
\end{aligned}$$

Conversely we may reduce a simple surd to an *entire surd*, *e.g.*

$$\begin{aligned}
14\sqrt{5} &= \sqrt{14^2} \times \sqrt{5} \\
&= \sqrt{196} \times \sqrt{5} \\
&= \sqrt{196 \times 5} \\
&= \sqrt{980}.
\end{aligned}$$

When surds have the same irrational factor they are said to be *like* or *similar* surds; *e.g.* $\sqrt{7}$ and $5\sqrt{7}$ are like surds. So also $5\sqrt[3]{2}$ and $6\sqrt[3]{16}$ are like surds, since $6\sqrt[3]{16}=6\sqrt[3]{8\times 2}=6(\sqrt[3]{8}\times\sqrt[3]{2})=6\times 2\sqrt[3]{2}=12\sqrt[3]{2}$.

We can add surds only when they are like. For example, $3\sqrt{45}+\sqrt{20}+7\sqrt{5}$

$$=(3\sqrt{9}\times\sqrt{5})+(\sqrt{4}\times\sqrt{5})+(7\sqrt{5})$$
$$=(3\times 3\sqrt{5})+(2\times\sqrt{5})+7\sqrt{5}$$
$$=9\sqrt{5}+2\sqrt{5}+7\sqrt{5}$$
$$=(9+2+7)\sqrt{5}$$
$$=18\sqrt{5}.$$

Find the value of $3\sqrt{147}-\frac{7}{3}\sqrt{\frac{1}{3}}-\sqrt{\frac{1}{27}}$.

Expression

$$=(3\sqrt{49}\times\sqrt{3})-(\tfrac{7}{3}\sqrt{\tfrac{1}{3}})-(\sqrt{\tfrac{1}{9\times 3}})$$
$$=(3\times 7\sqrt{3})-(\tfrac{7}{3}\sqrt{\tfrac{1}{3}})-(\sqrt{\tfrac{1}{9}}\times\sqrt{\tfrac{1}{3}})$$
$$=21\sqrt{3}-\tfrac{7}{3}\sqrt{\tfrac{3}{9}}-\tfrac{1}{3}\sqrt{\tfrac{3}{9}}$$
$$=21\sqrt{3}-(\tfrac{7}{3}\sqrt{\tfrac{1}{9}}\times\sqrt{\tfrac{3}{1}})-(\tfrac{1}{3}\sqrt{\tfrac{1}{9}}\times\sqrt{\tfrac{3}{1}})$$
$$=21\sqrt{3}-(\tfrac{7}{3}\times\tfrac{1}{3}\sqrt{3})-(\tfrac{1}{3}\times\tfrac{1}{3}\sqrt{3})$$
$$=21\sqrt{3}-\tfrac{7}{9}\sqrt{3}-\tfrac{1}{9}\sqrt{3}$$
$$=(21-\tfrac{7}{9}-\tfrac{1}{9})\sqrt{3}$$
$$=(21-\tfrac{8}{9})\sqrt{3}$$
$$=20\tfrac{1}{9}\sqrt{3}$$
$$=\frac{181}{9}\sqrt{3}.\quad 181\sqrt{3}$$

Multiplication of Surds.—In multiplying two surds of the same order we multiply the rational factors together and the irrational factors together. For example, $4\sqrt{2}\times 3\sqrt{3}=4\times 3\times\sqrt{2}\times\sqrt{3}=12\sqrt{2\times 3}=12\sqrt{6}$.

For

$$a\sqrt[3]{x}\times b\sqrt[3]{y}$$
$$=ax^{\frac{1}{3}}\times by^{\frac{1}{3}}$$
$$=abx^{\frac{1}{3}}y^{\frac{1}{3}}$$
$$=ab\sqrt[3]{x}\sqrt[3]{y}$$
$$=ab\sqrt[3]{xy}$$

Multiply $3\sqrt{8}$ by $\sqrt{6}$.

$$\text{Product}=3\sqrt{8\times 6}$$
$$=3\sqrt{48}$$
$$=3\sqrt{16\times 3}$$
$$=3\sqrt{16}\times\sqrt{3}$$
$$=3\times 4\times\sqrt{3}$$
$$=12\sqrt{3}.$$

Multiply $a\sqrt{b^3}$ by $b^2\sqrt{a}$.

$$\text{Product}=ab^2\sqrt{ab^3}$$
$$=ab^2\sqrt{ab^2b}$$
$$=ab^2b\sqrt{ab}$$
$$=ab^3\sqrt{ab}$$

Multiply $6\sqrt[3]{2}$ by $2\sqrt{5}$.

$$\text{Product}=(6\times 2^{\frac{1}{3}})\times(2\times 5^{\frac{1}{2}})$$
$$=(6\times 2^{\frac{2}{6}})\times(2\times 5^{\frac{3}{6}})$$
$$=6\sqrt[6]{2^2}\times 2\sqrt[6]{5^3}$$
$$=6\times 2\times\sqrt[6]{2^2\times 5^3}$$
$$=12\sqrt[6]{4\times 125^3}$$
$$=12\sqrt[6]{500}$$

Division of Surds.—Divide $3\sqrt{2}$ by $4\sqrt{3}$.

Arrange thus: $\dfrac{3\sqrt{2}}{4\sqrt{3}}$. Multiply numerator and denominator by some quantity that will make the denominator a whole number. Multiply by $\sqrt{3}$.

Then
$$\frac{3\sqrt{2}}{4\sqrt{3}}=\frac{3\sqrt{2}\times\sqrt{3}}{4\sqrt{3}\times\sqrt{3}}$$
$$=\frac{3\sqrt{2\times 3}}{4\sqrt{3\times 3}}$$
$$=\frac{3\sqrt{6}}{4\times 3}$$
$$=\frac{3}{12}\sqrt{6}=$$
$$=\tfrac{1}{4}\sqrt{6}$$
$$=\frac{\sqrt{6}}{4}$$

Divide $6\sqrt{3}$ by $5\sqrt[3]{12}$.

Multiply each by $\sqrt[3]{12}\times\sqrt[3]{12}$ and

$$\frac{6\sqrt{3}}{5\sqrt[3]{12}}=\frac{6\sqrt{3}\times\sqrt[3]{12}\times\sqrt[3]{12}}{5\sqrt[3]{12}\times\sqrt[3]{12}\times\sqrt[3]{12}}=\frac{6\sqrt{3}\times\sqrt[3]{12}\times\sqrt[3]{12}}{5\sqrt[3]{12\times 12\times 12}}$$
$$\frac{6\sqrt{3}\times\sqrt[3]{12\times 12}}{60}\quad\frac{\sqrt{3}\times\sqrt[3]{144}}{10}\quad\frac{\sqrt[6]{3^3}\times\sqrt[6]{144^2}}{10}$$
$$\frac{\sqrt[6]{3^3\times 144^2}}{10}=$$
$$\frac{\sqrt[6]{3^3\times(2\times 2\times 2\times 2\times 3\times 3)\times(2\times 2\times 2\times 2\times 3\times 3)}}{10}$$
$$=\frac{\sqrt[6]{3\times 3^6\times 2^6\times 2^2}}{10}=\frac{6\sqrt[6]{3\times 2^2}}{10}=\frac{3\sqrt[6]{12}}{5}=\tfrac{3}{5}\sqrt[6]{12}.$$

The aim in division of surds is to rationalise the denominator. The cube root of 12 ($\sqrt[3]{12}$)

does not come rational until it is multiplied by itself, and then by itself again.

Suppose we have to divide $\sqrt{4}+\sqrt{3}$ by $\sqrt{4}-\sqrt{3}$. How do we rationalise $\sqrt{4}-\sqrt{3}$? If we multiply $\sqrt{4}$ by $\sqrt{4}$ we obtain 4; similarly $\sqrt{3}\times\sqrt{3}=3$.

Multiply $\sqrt{4}-\sqrt{3}$ by $\sqrt{4}+\sqrt{3}$ and we have $(\sqrt{4})^2-(\sqrt{3})^2=4-3=1$.

Hence $$\frac{\sqrt{4}+\sqrt{3}}{\sqrt{4}-\sqrt{3}}=\frac{(\sqrt{4}+\sqrt{3})(\sqrt{4}+\sqrt{3})}{(\sqrt{4}-\sqrt{3})(\sqrt{4}+\sqrt{3})}$$
$$=\frac{(\sqrt{4}+\sqrt{3})^2}{4-3}$$
$$=\frac{4+2\sqrt{4}\sqrt{3}+3}{1}$$
$$=7+2\sqrt{4}\sqrt{3}$$
$$=7+2\times2\sqrt{3}$$
$$=7+4\sqrt{3}.$$

Simplify $\dfrac{2-\sqrt{3}}{2+\sqrt{3}}\times\dfrac{2\sqrt{3}}{\sqrt{3}-1}$ (Oxford Exam., 1899.)

Multiply 1st fraction by $\dfrac{2-\sqrt{3}}{2-\sqrt{3}}$ and 2nd by $\dfrac{\sqrt{3}+1}{\sqrt{3}+1}$.

Then expression

$$=\frac{(2-\sqrt{3})(2-\sqrt{3})}{(2+\sqrt{3})(2-\sqrt{3})}\times\frac{2\sqrt{3}\times(\sqrt{3}+1)}{(\sqrt{3}-1)(\sqrt{3}+1)}$$
$$=\frac{(2-\sqrt{3})^2}{4-3}\times\frac{2\sqrt{3}(\sqrt{3}+1)}{3-1}$$
$$=\frac{4-4\sqrt{3}+3}{1}\times\frac{2\sqrt{3}\sqrt{3}+2\sqrt{3}}{2}$$
$$=\frac{(7-4\sqrt{3})\times(6+2\sqrt{3})}{2}$$
$$=\frac{42+14\sqrt{3}-24\sqrt{3}-8\times3}{2}$$
$$=\frac{42-24-10\sqrt{3}}{2}$$
$$=\frac{18-10\sqrt{3}}{2}$$
$$=9-5\sqrt{3}.$$

A shorter and more direct way is to write expression thus:

$$\frac{2\sqrt{3}(2-\sqrt{3})}{(2+\sqrt{3})(\sqrt{3}-1)}=\frac{4\sqrt{3}-6}{1+\sqrt{3}}\text{ after multiplying out}$$
$$=\frac{(4\sqrt{3}-6)(1-\sqrt{3})}{(1+\sqrt{3})(1-\sqrt{3})}$$
$$=\frac{10\sqrt{3}-18}{1-3}$$
$$=\frac{10\sqrt{3}-18}{-2}$$
$$=\frac{18-10\sqrt{3}}{2}$$
$$=9-5\sqrt{3}.$$

Square Root of Binomial Surds

$$(\sqrt{a}+\sqrt{b})^2=(\sqrt{a})^2+2\sqrt{a}\sqrt{b}+(\sqrt{b})^2$$
$$=a+2\sqrt{ab}+b$$
$$=(a+b)+2\sqrt{ab}$$

= the sum of $(\sqrt{a})^2$ and $(\sqrt{b})^2$ and twice $\sqrt{a}$ into $\sqrt{b}$.

Let us find the square root of $\sqrt{9-\sqrt{80}}$.

Suppose $\sqrt{a}-\sqrt{b}$ is the square root; then $\sqrt{9-\sqrt{80}}=\sqrt{a+b-2\sqrt{ab}}$, so that $a+b=9$ and $2\sqrt{ab}=\sqrt{80}=\sqrt{4\times20}=2\sqrt{20}$.

a and b must be two numbers whose sum is 9 and whose product is 20. By inspection 5 and 4 are these numbers. Hence

$$\sqrt{9-\sqrt{80}}=\sqrt{5+4-2\sqrt{5\times4}}$$
$$=\sqrt{5}-\sqrt{4}$$
$$=\sqrt{5}-2.$$

By inspection we can write down $\sqrt{6-\sqrt{35}}$.

$$\sqrt{6-\sqrt{35}}=\sqrt{\frac{(6-\sqrt{35})\times2}{2}}=\sqrt{\frac{12-2\sqrt{35}}{2}}.$$

We have to find two numbers whose sum is 12 and whose product is 35; 7 and 5 are these numbers.

$$\sqrt{\frac{12-2\sqrt{35}}{2}}=\frac{\sqrt{7}-\sqrt{5}}{\sqrt{2}}=\frac{\sqrt{2}(\sqrt{7}-\sqrt{5})}{\sqrt{2}\times\sqrt{2}}$$
$$=\frac{\sqrt{14}-\sqrt{10}}{2}=\tfrac{1}{2}(\sqrt{14}-\sqrt{10}).$$

Find the square root of $8+4\sqrt{3}$.

$$8+4\sqrt{3}=2(4+2\sqrt{3})$$
$$\sqrt{8+4\sqrt{3}}=\sqrt{2(4+2\sqrt{3})}$$
$$=\sqrt{2}\times\sqrt{4+2\sqrt{3}}$$

Find numbers whose sum is 4 and product 3. They are 3 and 1.

$$=\sqrt{2}(\sqrt{3}+\sqrt{1})$$
$$=\sqrt{2}\sqrt{3}+\sqrt{2}\sqrt{1}$$
$$=\sqrt{6}+\sqrt{2}.$$

Find the square root of $a^2+\sqrt{a^4-b^4}$

$$\sqrt{a^2+\sqrt{a^4-b^4}}=\sqrt{\frac{2a^2+2\sqrt{a^4-b^4}}{2}}$$

Find two numbers whose sum is $2a^2$ and whose product is a^4-b^4. These are a^2+b^2 and a^2-b^2.

$$=\frac{\sqrt{a^2+b^2}+\sqrt{a^2-b^2}}{\sqrt{2}}$$
$$=\sqrt{\frac{a^2+b^2}{2}}+\sqrt{\frac{a^2-b^2)}{2}}$$

The square root of a rational quantity cannot be partly rational and partly a quadratic surd.

Let k be a rational quantity and suppose its square root is $a+\sqrt{t}$.

Then $\sqrt{k}=a+\sqrt{t}$. Square each side and

$$k=a^2+2a\sqrt{t}+t,$$

or $2a\sqrt{t}=a^2+t-k$;

$$\sqrt{t}=\frac{a^2+t-k}{2a}$$

i.e. a rational quantity is equal to a surd, which is impossible.

If $x+\sqrt{k}=a+\sqrt{b}$, then $x=a$ and $\sqrt{k}=\sqrt{b}$.

For if x is not equal to a, let $x=a+t$.

Then $a+t+\sqrt{k}=a+\sqrt{b}$,

i.e. $\sqrt{b}=t+\sqrt{k}$, which is impossible.

Therefore $x=a$ and $\sqrt{k}=\sqrt{b}$, and if $x+\sqrt{k}=a+\sqrt{b}$, then $x-\sqrt{k}=a-\sqrt{b}$.

Equations involving Surds.

Solve $7-\sqrt{x-4}=3$.

Transpose, and $7-3=\sqrt{x-4}$

i.e. $4=\sqrt{x-4}$. Square each side and $16=x-4$

$$\therefore\ x=20.$$

Solve $\sqrt{3x+2}+\sqrt{3x-1}=\sqrt{6x+5}$.

(L.C. higher, 1912.)

Square each side and

$$3x+2+2\sqrt{3x+2}\cdot\sqrt{3x-1}+3x-1=6x+5$$
$$2\sqrt{3x+2}\sqrt{3x-1}=4$$
$$\sqrt{3x+2}\cdot\sqrt{3x-1}=2$$

Square both sides and

$$(3x+2)(3x-1)=4$$
$$9x^2+3x-2=4$$
$$9x^2+3x-6=0$$
$$3x^2+x-2=0$$
$$(3x-2)(x+1)=0$$
$$\therefore\ x=\tfrac{2}{3}\text{ or }-1.$$

But on trial the root -1 is not admissible.

PROBLEMS

Pipes and Cisterns.—A pipe can fill a cistern in 4 hours, another pipe can fill it in 5 hours. How long will they take to fill it if both are open ?

Call the first pipe A, the second pipe B.

A fills the cistern in 4 hours,
$\therefore$ A fills $\frac{1}{4}$ of the cistern in 1 hour.
B fills the cistern in 5 hours,
$\therefore$ B fills $\frac{1}{5}$ of the cistern in 1 hour.

In 1 hour the part filled is $\frac{1}{4}+\frac{1}{5}$, *i.e.* $\frac{5}{20}+\frac{4}{20}$, or $\frac{9}{20}$ of the cistern.

$\frac{9}{20}$ take 1 hour to fill
$\frac{1}{20}$ takes $\frac{1}{9}$,,
$\frac{20}{20}$ take $\frac{20}{9}$,,

But $\frac{20}{20}$ is the whole cistern. $\therefore$ the cistern is filled in $\frac{20}{9}$ or $2\frac{2}{9}$ hours.

Two pipes A and B can fill a cistern in 3 hours and 4 hours respectively ; another pipe C can empty the cistern in 5 hours. If all three are opened at once, how long will the cistern take to fill ?

At the end of 1 hour A has filled $\frac{1}{3}$ of the cistern.

At the end of 1 hour B has filled $\frac{1}{4}$ of the cistern.

Hence in 1 hour A and B fill $\frac{1}{3}+\frac{1}{4}$, or $\frac{7}{12}$ of the cistern. But during this hour C has been emptying $\frac{1}{5}$ of the cistern.

Hence at the end of the hour $\frac{7}{12}-\frac{1}{5}$ of the cistern, *i.e.* $\frac{35}{60}-\frac{12}{60}$, or $\frac{23}{60}$ of the cistern is filled.

$\frac{23}{60}$ of the cistern is filled in 1 hour.
$\frac{1}{60}$,, ,, ,, $\frac{1}{23}$,,
$\frac{60}{60}$,, ,, ,, $\frac{60}{23}$ hours or $2\frac{14}{23}$ hours.

Answer : $2\frac{14}{23}$ hours.

"Work" Problems.—A can build a wall in 5 days, B in 6 days, and C in 7 days. How long will they take working together ?

A builds $\frac{1}{5}$ of the wall in 1 day.
B ,, $\frac{1}{6}$,, ,, ,,
C ,, $\frac{1}{7}$,, ,, ,,

$\therefore$ A+B+C build $\frac{1}{5}+\frac{1}{6}+\frac{1}{7}$ of the wall in 1 day.

$$\frac{1}{5}+\frac{1}{6}+\frac{1}{7}=\frac{42}{210}+\frac{35}{210}+\frac{30}{210}$$
$$=\frac{107}{210}$$

$\frac{107}{210}$ of the wall is built in 1 day,

$\frac{1}{210}$ „ „ „ $\frac{1}{107}$ days

$\frac{210}{210}$ „ „ „ $\frac{210}{107}$ or $1\frac{103}{107}$ days.

A, B, and C together build the wall in $1\frac{103}{107}$ days.

A and B dig a trench in 3 days, B and C in 4 days, C and A in 2 days. How long will each man take to do the work alone ?

A+B do the work in 3 days, $\therefore$ they do $\frac{1}{3}$ of the work in 1 day.

So B+C do $\frac{1}{4}$ of the work in 1 day
C+A „ $\frac{1}{2}$ „ „ „ 1 „

$\therefore$ A+B+B+C+C + A, *i.e.* 2(A+B+C) do $\frac{1}{3}+\frac{1}{4}+\frac{1}{2}$ or $\frac{4}{12}+\frac{3}{12}+\frac{6}{12}$, *i.e.* $\frac{13}{12}$ in 1 day.

$2(A+B+C)=\frac{13}{12}$. Divide each side by 2.

Then $A+B+C=\frac{13}{12\times 2}=\frac{13}{24}$.

A, B, and C working together do $\frac{13}{24}$ of the work in 1 day. But A+B do $\frac{1}{3}$ of the work in 1 day.

$\therefore$ C does $\frac{13}{24}-\frac{1}{3}$ or $\frac{13}{24}-\frac{8}{24}$ or $\frac{5}{24}$ in 1 day.

B „ $\frac{13}{24}-\frac{1}{2}$ or $\frac{13}{24}-\frac{12}{24}$ or $\frac{1}{24}$ „

A „ $\frac{13}{24}-\frac{1}{4}$ or $\frac{13}{24}-\frac{6}{24}$ or $\frac{7}{24}$ „

C does $\frac{5}{24}$ in 1 day, $\therefore$ he takes $\frac{24}{5}$ or $4\frac{4}{5}$ days to do the work.

B does $\frac{1}{24}$ in 1 day, $\therefore$ he takes $\frac{24}{1}$ or 24 days to do the work.

A does $\frac{7}{24}$ in 1 day, $\therefore$ he takes $\frac{24}{7}$ or $3\frac{3}{7}$ days to do the work.

Answer : A, $3\frac{3}{7}$ days ; B, 24 days ; C, $4\frac{4}{5}$ days.

A and B sweep a street in 45 minutes. If A worked half as fast again he could sweep it alone in 90 minutes. In how many minutes could B sweep it alone ?

A+B sweep $\frac{1}{45}$ of the street in 1 minute.

Suppose that A take x minutes if he work alone. Then he will sweep $\frac{1}{x}$ of the street in a minute. If he is working half as fast again he will sweep $\left(\frac{1}{x}+\frac{1}{2}\text{ of }\frac{1}{x}\right)$ of the street in 1 minute.

$$\frac{1}{x}+\frac{1}{2}\text{ of }\frac{1}{x}=\frac{1}{x}+\left(\frac{1}{2}\times\frac{1}{x}\right)$$
$$=\frac{1}{x}+\frac{1}{2x}$$
$$=\frac{2}{2x}+\frac{1}{2x}$$
$$=\frac{3}{2x}$$

A does $\frac{3}{2x}$ of the work in 1 minute.

„ the whole work in $\frac{2x}{3}$ minutes.

But we know he takes 90 minutes.

$$\therefore \frac{2x}{3}=90 \text{ minutes}$$
$$2x=270 \quad „$$
$$x=135 \quad „$$

Hence A does the work in 135 minutes; in 1 minute he does $\frac{1}{135}$ of the work. But A+B do $\frac{1}{45}$ in 1 minute.

$\therefore$ B does $\frac{1}{45}-\frac{1}{135}$ or $\frac{3}{135}-\frac{1}{135}$ or $\frac{2}{135}$ of the work in 1 minute. For the whole work he takes $\frac{135}{2}$ minutes, or $67\frac{1}{2}$ minutes.

If 4 men can do a piece of work in 15 days which 6 women can do in 14 days, how long will 5 men and 7 women working together take to do the same ?

4 men do the work in 15 days,
„ $\frac{1}{15}$ of the work in 1 day.
1 man does $\frac{1}{15}\div 4$ or $\frac{1}{60}$ of the work in 1 day,
5 men do $\frac{5}{60}$ of the work in 1 day.
6 women do the work in 14 days,
„ $\frac{1}{14}$ of the work in 1 day.
1 woman does $\frac{1}{14}\div 6$ or $\frac{1}{84}$ of the work in 1 day,
7 women do $\frac{7}{84}$ of the work in 1 day.

$\therefore$ 5 men + 7 women do $\frac{5}{60}+\frac{7}{84}$, *i.e.* $\frac{1}{12}+\frac{1}{14}$ or $\frac{13}{84}$ of the work in 1 day. Hence they do the whole work in $\frac{84}{13}$ days, *i.e.* $6\frac{6}{13}$ days.

"Train" Sums.—A train 176 yards is travelling at a speed of 60 miles per hour. How long does it take to pass a telegraph pole ?

$$60 \text{ miles per hour} = 60\times 1760 \text{ yds. per hour}$$
$$=60\times 1760\times 3 \text{ ft. per hour.}$$
$$=\frac{60\times 1760\times 3}{60}\text{ ft. per min.}$$
$$=\frac{\cancel{60}\times \overset{88}{\cancel{1760}}\times \cancel{3}}{\cancel{60}\times \underset{20}{\cancel{60}}}\text{ ft. per sec.}$$
$$=88 \text{ ft. per sec.}$$

Length of train = 176 yds. = 176 × 3 ft. = 528 ft.

Stick a pin into the table ; imagine your pen is a train and push the pen past the pin. The pen point (the engine) has to go the length of the pen (train) before the end of the pen (the guard's van) is at the pin (telegraph pole). In short, the pen (train) travels its own length in passing the pin (telegraph pole).

The train's length is 528 feet. How long will it take to go its own length ?

It goes 88 ft. in 1 sec.
„ 1 foot in $\frac{1}{88}$ sec.
„ 528 ft. in $\frac{528}{88}$, or 6 seconds.

An express 80 yards long, travelling 40 miles per hour, meets a goods train 100 yards long travelling 30 miles per hour. How long do they take to pass each other ?

The trains approach each other at a rate of 40+30 miles, or 70 miles per hour. We may suppose that the goods is stationary and the

express is passing it at 70 miles per hour. Draw two straight lines to represent the trains.

Express (80 yds.).

A ⟶

Goods (100 yds.).

⟵ B

Let A be the guard's van of the express, and B the guard's van of the goods. By the time A reaches B it must have travelled the sum of the lengths, or $80+100$, *i.e.* 180 yards.

Now we imagine the goods is standing still and the express is travelling at 70 miles per hour. How long will the express take to go 180 yards, or 540 feet ?

60 miles per hour = 88 ft. per sec.

$$1 \text{ mile} \quad ,, \quad = \frac{88}{60} \quad ,, \quad ,,$$

$$70 \text{ miles} \quad ,, \quad = \frac{\overset{44}{\cancel{88}} \times 7\cancel{0}}{\underset{3}{\cancel{60}}} \text{ or } \frac{308}{3} \text{ ft. per sec.,}$$

We have to find how long the express, travelling at 70 miles per hour, takes to go 180 yards or 180×3 feet.

The express goes $\frac{308}{3}$ ft. in 1 sec.

$$,, \quad ,, \quad 1 \text{ ft. in } \frac{1}{\frac{308}{3}} \text{ secs.}$$

$$,, \quad ,, \quad 540 \text{ ft. in } \frac{1 \times 540}{\frac{308}{3}} \text{ secs.}$$

$$= 540 \div \tfrac{308}{3} \text{ secs.}$$

$$= \frac{\overset{135}{\cancel{540}} \times 3}{\underset{77}{\cancel{308}}} \quad ,,$$

$$= \frac{405}{77} \quad ,,$$

$$= 5\tfrac{20}{77} \text{ seconds.}$$

Hence the trains take $5\frac{20}{77}$ seconds to pass each other.

An express 75 yards long travelling 48 miles per hour overtakes a goods 105 yards long travelling at 30 miles per hour. How long will it take to pass ?

The express passes the goods at the rate of $48-30$ miles an hour, *i.e.* 18 miles per hour. Imagine the goods to be stationary and the express to pass it at 18 miles per hour.

Let A be the guard's van of the express, and K the goods engine.

Express (75 yds.)

A ⟶

Goods (105 yds.).

⟶ K

A in moving to K must move through $75+105$ yards, the sum of the train lengths.

The rate is 18 miles per hour.

60 miles per hour = 88 ft. per sec.

$$1 \text{ mile} \quad ,, \quad = \frac{88}{60} \quad ,,$$

$$18 \text{ miles} \quad ,, \quad = \frac{88 \times 18}{60} \text{ ft. per sec.}$$

The express goes $\frac{88 \times 18}{60}$ feet per second, how long will it take to go $75+105$ yards, *i.e.* 540 feet ?

It goes $\frac{88 \times 18}{60}$ ft. in 1 sec.

$$,, \quad 1 \text{ foot in } \frac{1}{\frac{88 \times 18}{60}} \text{ secs.}$$

$$,, \quad 540 \text{ ft. in } \frac{1 \times 540}{\frac{88 \times 18}{60}} \quad ,,$$

$$= 540 \div \frac{88 \times 18}{60} \text{ secs.}$$

$$= \frac{\overset{15}{\cancel{540}} \times \overset{15}{\cancel{60}}}{\underset{11}{\cancel{88}} \times \underset{2}{\cancel{18}}} = \frac{225}{11} = 20\tfrac{5}{11} \text{ seconds.}$$

A train going 30 miles per hour passes a man walking in the same direction at 3 miles per hour, and goes by him in 10 seconds. What is the length of the train ?

The train passes him at the rate of $30-3$ miles per hour, *i.e.* 27 miles per hour.

In 1 hour or 60×60 seconds train goes 27 miles.

In 1 second train goes $\frac{27}{60 \times 60}$ miles.

In 10 seconds train goes $\frac{\overset{3}{\cancel{27}} \times 1\cancel{0}}{\underset{2}{\cancel{60}} \times \underset{20}{\cancel{60}}}$ miles.

or $\frac{3}{40}$ mile.

$$\frac{3}{40} \text{ mile} = \frac{3}{40} \times 1760 \times 3 \text{ ft.}$$

$$= \frac{3 \times \overset{44}{\cancel{1760}} \times 3}{\cancel{40}} \quad ,,$$

$$= 396 \quad ,,$$

$$= 132 \text{ yards.}$$

In 10 seconds the train goes 132 yards, but in passing the man it goes its own length. Hence length of train is 132 yards.

A train 176 feet long is travelling at 45 miles per hour and it overtakes a train going at 30 miles per hour. How long does the first train take to pass a passenger in the second train ?

The trains are travelling in the same direction, hence the fast passes the slow at a rate of 45−30, or 15 miles per hour. The fast train in passing the passenger in the slow train must go its own length, 176 feet. How long will it take ?

It goes 15 miles per hour (*i.e.* $\frac{1}{4}$ of 60 miles per hour) or 22 feet per second.

It goes 22 ft. in 1 sec.

" 1 foot in $\frac{1}{22}$ sec.

" 176 ft. in $\frac{176}{22}$ secs., or 8 seconds.

Races and Games.—In most races all competitors start from the starting line. If a great runner were to run against a mediocre runner, the sports committee would arrange for a *handicap race*. In a handicap race the poorer runner gets a start. The great runner has to start from "scratch," *i.e.* the starting line, but the other man has, say, 100 yards of a start in a mile race. The good runner has to run 1760 but the poor runner has to run only 1660 yards. In a problem if we are told that A can beat B by 90 yards in a mile race, we may imagine B to have 90 yards of a start. A runs 1760 yards, B runs 1760−90, or 1670 yards. Both will reach the tape at the same instant.

In a mile race A can beat B by 80 yards, B can beat C by 80 yards ; by how many yards can A beat C in a mile race ?

A beats B by 80 yards, ∴ while A runs 1760 yards B runs 1680 yards.

B beats C by 80 yards, ∴ while B runs 1760 yards C runs 1680 yards.

Find how far C runs while B runs 1680 yards.

While B runs 1760 yds. C runs 1680 yds.

1 yd. $\frac{1680}{1760}$ "

$$1680 \text{ yds.} \qquad \frac{\overset{\overset{21}{\cancel{42}}}{\cancel{1680}} \times \overset{840}{\cancel{1680}}}{\underset{\underset{\underset{11}{\cancel{22}}}{\cancel{44}}}{\cancel{1760}}} \text{ yds.}$$

$=1603\frac{7}{11}$ yards.

If A, B, and C all run together a mile race, when A has gone 1760 yards B will have gone 1680 yards, and C $1603\frac{7}{11}$ yards. A therefore beats C by $1760-1603\frac{7}{11}$, or $156\frac{4}{11}$ yards.

In a mile race A beats B by 32 yards and C by 48 yards. By how much can B beat C in a race of 1080 yards ?

A goes 1760 yards while B goes 1760−32 or 1728 yards, and C goes 1760−48 or 1712 yards. Thus in a race of 1728 yards B beats C by 1728−1712 or 16 yards.

In a race of 1728 yards, B beats C by 16 yards.

In a race of 1080 yards, B beats C by

$$\cancel{16} \times \frac{\overset{10}{\cancel{1080}}}{\underset{\cancel{108}}{\cancel{1728}}} \text{ yards}$$

or $\underline{10}$

In a mile race A beats B by 20 yards, and C by 30 yards. By how many yards could B beat C in a race of a mile ?

Let us work by ratio. While A runs 1760 yards, B runs 1740 yards, ∴ A's rate is to B's rate as 1760 is to 1740. This is expressed .

$$\frac{A}{B}=\frac{1760}{1740}$$

Similarly $\frac{A}{C}=\frac{1760}{1730}$

So $\frac{A}{B}$ is to $\frac{A}{C}$ as $\frac{1760}{1740}$ is to $\frac{1760}{1730}$

or $$\frac{\frac{A}{B}}{\frac{A}{C}}=\frac{\frac{1760}{1740}}{\frac{1760}{1730}}$$

that is $$\frac{A}{B}\div\frac{A}{C}=\frac{1760}{1740}\div\frac{1760}{1730}$$

$$\frac{A}{B}\times\frac{C}{A}=\frac{\cancel{1760}}{1740}\times\frac{1730}{\cancel{1760}}$$

$$\frac{C}{B}=\frac{1730}{1740}$$

$$\frac{B}{C}=\frac{174}{173}$$

or B is to C as 174 is to 173.

While B runs 174 yards, C runs 173 yards.

While B runs 1760 yards, C runs $\frac{173\times\overset{880}{\cancel{1760}}}{\underset{87}{\cancel{174}}}$ yards

or $1749\frac{77}{87}$ yards.

B thus beats C by $1760-1749\frac{77}{87}$ or $10\frac{10}{87}$ yards in a mile race.

A can beat B by 40 yards in a mile. If A starts from scratch and B has 15 yards' start, what distance will each have covered when they are exactly level ?

A gains 40 yards on B in a race of 1760 yards.

A gains 1 yard on B in a race of $\frac{1760}{40}$ yards.

A gains 15 yards on B in a race of

$$\frac{1760\times15}{40}=660 \text{ yards.}$$

When A is 660 yards from scratch, he is level with B. But B started 15 yards in front of scratch, hence B covers 660−15 or 645 yards.

An express A travelling 50 miles an hour leaves Edinburgh for London at 9 A.M. At the same hour an express travelling at 60 miles an hour leaves London for Edinburgh. If the distance between the two cities is 405 miles, which is farthest from London when they meet ?

This appears to be a difficult problem, but in reality it is a "catch." Suppose the trains meet at York, then both are the same distance from London.

"Stream" Sums.—A man can row 4 miles an hour on still water. Suppose he rows down a stream flowing at the rate of 2 miles an hour. In 1 hour he will row 4 miles, but the stream will have carried him 2 miles down, hence he will be 6 miles down stream. Hence his rate with the stream is $4+2$ miles per hour.

Rate with stream = rate in still water + rate of current.

So rate against stream = rate in still water − rate of current.

Let r be rate in still water and c the current.

Then $r+c$ = rate down stream,

$r-c$ = rate up stream.

Add, then $2r$ = rate down stream + rate up stream.

Then divide each side by 2, and

$r=\frac{1}{2}$ (rate down stream + rate up stream).

Rate in still water = $\frac{1}{2}$ the sum of the rate with and against the current.

If a man rows 16 miles in 6 hours against a stream, which flows at $3\frac{1}{2}$ miles per hour, in what time will he perform the return journey ?

16 miles in 6 hour $=2\frac{2}{3}$ miles in 1 hour.

Rate up stream = rate in still water − rate of stream,

$2\frac{2}{3}$ = rate in still water $-3\frac{1}{2}$,

transpose $2\frac{2}{3}+3\frac{1}{2}$ = „ „

$2\frac{4}{6}+3\frac{3}{6}$ = „ „

$6\frac{1}{6}$ = „ „

Rate down stream = rate in still water + rate of stream

$=6\frac{1}{6}+3\frac{1}{2}$

$=6\frac{1}{6}+3\frac{3}{6}$

$=9\frac{4}{6}$

$=9\frac{2}{3}$ miles per hour.

Coming back he does $9\frac{2}{3}$ miles in 1 hour,

„ „ 1 mile in $\dfrac{1}{9\frac{2}{3}}$ hours,

„ „ 16 miles in $\dfrac{16}{9\frac{2}{3}}=\dfrac{16\times 3}{29}$

$=\dfrac{48}{29}=1\dfrac{19}{29}$ hours.

Answer.— $1\frac{19}{29}$ hours.

A man rows 10 miles down stream in 2 hours, and he can row 6 miles up stream in the same time. Find his rate in still water and rate of current.

Rate with current = 10 miles in 2 hrs. = 5 miles an hour

„ against „ = 6 miles in 2 hrs. = 3 miles an hour.

Rate in still water $=\frac{1}{2}$ (sum of rate with and against current)

$=\frac{1}{2}(5+3)$

$=4$ miles per hour.

Rate with current = 5 miles per hour = rate in still water + rate of current = 4 + rate of current.

∴ 4 + rate of current = 5 miles per hour.

∴ rate of current $=5-4=1$ mile per hour.

A man rows 18 miles down stream in 4 hours and returns in 12 hours. Find his rate in still water and also the rate of the stream.

He rows 18 miles down stream in 4 hours, ∴ rate with stream $=4\frac{1}{2}$ miles per hour.

He rows 18 miles up stream in 12 hours, ∴ rate up stream $=1\frac{1}{2}$ miles per hour.

Rate down stream, *i.e.* $4\frac{1}{2}$ = rate in still water + rate of stream.

Rate up stream, *i.e.* $1\frac{1}{2}$ = rate in still water − rate of stream.

Add, $4\frac{1}{2}+1\frac{1}{2}=2$ (rate in still water),

∴ $6=2$ (rate in still water),

3 = rate in still water.

Now rate down stream = rate in still water + rate of current,

that is $4\frac{1}{2}=3$ + rate of current.

Transpose $4\frac{1}{2}-3$ = rate of current

$1\frac{1}{2}$ = rate of current.

Answer.—3 miles ; $1\frac{1}{2}$ miles.

Clock Sums.—In a clock the minute hand (M.H.) moves over 60 minute spaces, while the hour hand (H.H.) moves over 5 minute spaces. The M.H. thus gains 55 spaces on the H.H. in 1 hour.

How soon after 12 o'clock will the hands of a watch be together ? At 12 o'clock the hands are together. By the time that they are together again the large hand M.H. must have gone once round the clock's 60 spaces. Now in 1 hour the M.H. gains 55 spaces on the H.H. How long will it take to gain 60 spaces ?

55 spaces take 1 hour.

60 „ $\dfrac{\overset{12}{\cancel{60}}}{\underset{11}{\cancel{55}}}$ hrs., $1\frac{1}{11}$ hrs., or 1 hr. 5 mins. $27\frac{3}{11}$ secs.

$1\frac{1}{11}$ hours after 12 is 5 minutes $27\frac{3}{11}$ seconds past 1.

Find the time between 3 and 4 o'clock when the angle between the two hands of a watch is a right angle.

At 3 o'clock the hands are at right angles to

each other, and the M.H. is 15 minute spaces behind the H.H. When next they are at right angles the M.H. must have gained 30 minutes on the H.H. How long will it take to gain 30 minutes?

It gains 55 spaces in 1 hr. or 3600 secs.

$$\text{,,} \quad 30 \quad \text{,,} \quad 3600 \times \frac{\overset{6}{\cancel{30}}}{\underset{11}{\cancel{55}}} = \frac{21600}{11} \text{ secs.}$$

$$\therefore \quad \text{Time} = \frac{\overset{360}{\cancel{21600}}}{11 \times \cancel{60}} \text{ mins.} = 32\tfrac{8}{11} \text{ mins. past 3.}$$

A watch, set correctly at noon, indicates 10 minutes past 9 the same evening when the true time is 10. What is the true time when the watch indicates 11 that evening?

In 10 hours the watch loses 50 minutes, hence 9 hours 10 minutes on the watch = 10 hours correct time.

$$11 \text{ hrs. on the watch} = \quad \times \frac{11}{9\frac{1}{6}}$$

$$= \frac{\overset{2}{\cancel{10}}}{1} \times \frac{\cancel{11}}{1} \times \frac{6}{\underset{5}{\cancel{55}}} = 12 \text{ hrs.}$$

The true time is therefore midnight.

GEOMETRY

In studying geometry we accept certain truths which are self-evident, and we call these truths *axioms*. We say, for instance; *Things which are equal to the same thing are equal to one another*. To prove this would be as useless as to prove that Mr. Brown is not Mr. Smith.

The axioms we use in geometry correspond to the primary rules of arithmetic. They are:

(1) If equals be added to equals the sums are equal.

(2) If equals be taken from equals the remainders are equal.

(3) The same multiples of equals are equal to one another.

(4) The same parts of equals are equal to one another.

The Point.—Suppose I make a tiny hole with a pin on the top of a table. I ask a boy to tell me the size of the hole. He will probably reply: "It has no size at all; it has no length or no breadth. It simply marks a position." The geometrical definition is: A *point* has position but no magnitude. Clearly this definition is not exact: the smallest point made with the sharpest needle or pencil has some length and breadth.

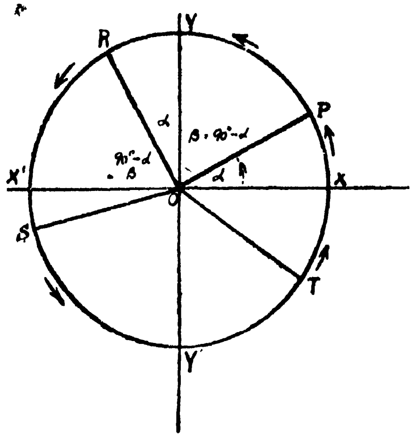
The Line.—If a snail crawls across the floor it leaves a trail behind it. So if a pencil is drawn across a page it leaves a trail behind it. A line should be looked upon as being traced by a moving point. In geometry we say that a line has length but no thickness, but the finest line has some thickness.

If the snail keeps moving in one direction—say, due north—its trail is straight; hence a *straight line* is a line traced by a point that moves in one direction. A crooked or curved line is always changing its direction.

If the snail moves from a point A to a point B, keeping one direction during the journey, he leaves a trail which is straight. It is obvious that whenever the snail wants to go straight from A to B it will traverse the same path. In other words, there can be only one straight line joining two points, since a straight line is the shortest distance between two points.

The Angle.—When two straight lines meet at a point they form an angle. A child might define an angle as a corner, but in geometry an angle is associated with *rotation*.

The figure is a clock face; O is the centre, and OX is a hand. If the hand be moved backwards



to the position OP, the movement is a rotatory one, *i.e.* O remains fixed. OX is said to have moved through an angle, and the angle is called the angle XOP. Let OX be moved to the position OY, so that OY is perpendicular to OX. The new angle is the angle XOY. Angles are measured by degrees. If the line OX is rotated right round in a circle it travels through 360 degrees (written 360°) before it again reaches its first position. A glance will tell that OX has moved through $\frac{1}{4}$ of 360°, *i.e.* 90°, when it takes up the position OY. The angle XOY (usually written $\angle$XOY or XOY) is an angle of 90°, and an angle of 90° is called a right angle. An angle which is less than a right angle is called an *acute angle*—*e.g.* $\angle$XOP. An angle greater than a right angle but less than 2 right angles (180°) is an *obtuse angle*—*e.g.* $\angle$XOR.

When OX has taken up the position OX¹ it has rotated through a half-circle, *i.e.* a semi-circle. Evidently it has rotated through 180° or 2 right angles. What angle does it make with OX? Here the child's definition of an angle as a corner fails, for XOX¹ is a straight line. The angle XOX¹ is known as a straight angle, and a straight angle contains 180°. When OX reaches the position OS it has rotated through more than 180°. The angle XOS is known as a *reflex angle*. So also the angle XOT is a reflex angle.

Note that when the hand has taken the

position OY^1 it has rotated through $90+90+90$ degrees, or $270°$.

The above figure shows us facts that are evident without proof. The line XOX^1 is a straight line; similarly YOY^1 is a straight line. These straight lines cut one another (intersect) at right angles. For $\angle XOY=90°$, $\angle X^1OY=90°$, $\angle X^1OY^1=90°$, $\angle XOY^1=90°$. Hence $\angle XOY=\angle X^1OY=\angle X^1OY^1=\angle XOY^1$.

Hence if one straight line (OY) is perpendicular to another straight line (XOX^1) the adjacent angles (XOY and X^1OY) are equal to one another, and each is a right angle.

Again, consider the angle XOP. Add to it $\angle POY$, and $\angle XOP+\angle POY=XOY=\angle 90°$.

Transpose, and $\angle XOP=90°-\angle POY$. Call $\angle XOP$ α, and $\angle POY$ β.

Then $\alpha=90°-\beta$.
Similarly $\beta=90°-\alpha$.

A set-square will show that in this figure OR is perpendicular to OP, hence $\angle ROP$ is a right angle.

$$\therefore \quad \angle YOR=\angle ROP-\angle POY$$
$$=90°-\beta$$
$$=\alpha$$
$$=\angle XOP.$$

We can also show that $\angle X^1OR=\angle YOP=\beta$.

$$\angle X^1OR=\angle X^1OY-\angle ROY$$
$$=90°-\alpha$$
$$=\beta$$
$$=\angle YOP.$$

When two angles are separated by an arm (*e.g.* $\angle XOP$ and $\angle POY$, separated by OP), the angles are said to be *adjacent* to each other. When two straight lines cross one another, the angles made are said to be *vertically opposite*, *e.g.* $\angle XOY$ is vertically opposite to $\angle X^1OY^1$, so $\angle X^1OY$ is vertically opposite to $\angle XOY^1$.

Is $\angle X^1OR$ vertically opposite to $\angle XOT$? It is not, for although XOX^1 is a straight line, ROT is not a straight line.

Fig. 1 may be used to illustrate the definitions relating to the circle, but before we define a circle we must define a *plane*. A *plane* is a flat surface, such that if any two points be taken on that surface, the straight line joining them lies wholly in that surface. A page of this book is a plane; if I make two dots on this page, the straight line joining them must lie on the surface of the page.

A circle is a plane figure bounded by a line traced out by a point which moves so that its distance from a given fixed point is constant, *i.e.* always the same. In Fig. 1 the point X moved and took up the positions P, Y, R, X^1, S, &c. The line traversed by the point X is called the *circumference* of the circle; the point O is the *centre* of the circle. The line OX is known as a *radius* of the circle XYX^1Y^1; hence OP is a radius, and OY, OR, OX^1, OS, &c., are radii. Since OY, OR, OX^1, &c., represent the hand OX turned round counter-clockwise, it follows that all radii of a circle are equal.

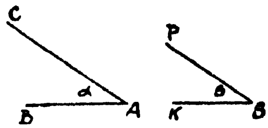
A *diameter* of a circle is a straight line which passes through the centre and is terminated at each side by the circumference. XOX^1 and YOY^1 are diameters of the circle XYX^1Y^1. Is POS a diameter? Obviously not, since PO and OS do not form one straight line.

A *semicircle* is a half-circle. XYX^1, YX^1Y^1, X^1Y^1X, Y^1XY are semicircles. An *arc* of a circle is any part of its circumference, *e.g.* XP, PY, YR, &c. Is a semicircle an arc? No; the arc XYX^1 is the part of the circumference a fly would traverse if walking round from X to X^1, but the semicircle XYX^1 is the whole space enclosed by the arc XYX^1 and the diameter XOX^1.

In geometry we take it for granted that we may halve or bisect a line or an angle just as we halve an apple. We also take it for granted that:

(1) A straight line may be drawn from any one point to any other point.
(2) A finite straight line (*i.e.* a straight line of fixed length) may be produced to any length.
(3) A circle may be drawn with any point as centre and with any length as radius.

The above are known as *Postulates*. Excepting these self-evident facts, we take nothing for granted; we must prove all things by theory. I can take a set-square and make two angles of 45° each; but although I prove by measurement that these angles are equal, I am not proving their equality by geometry. Yet geometry allows me to take a pair of scissors, cut out one angle and place it or *superpose* it on the other. We call this process *superposition*, and we *apply* one figure to the other.



α and β are two angles. I cut out α, and lay it on β, so that AB lies along SK. Then if $\alpha=\beta$, AC will lie along SP. This figure shows that the length of the arms does not affect the size of the angle. KS is obviously shorter than AB, yet the $\angle BAC=\angle KSP$.

Theorems and Problems.—A *Theorem* proves the truth of a geometrical statement; a *Problem* performs some construction. An example of a theorem is: *If two straight lines cut one another, the vertically opposite angles are equal.* This is stated as a fact; all we have to do is to prove the fact. On the other hand, the following is a problem: *To draw a straight line perpendicular to a given straight line from a given external point.* Here we have to *construct* a figure.

Lines and Angles

The adjacent angles which one straight line makes with another on one side of it are together

equal to two right angles. (Euclid, I, 13.—A Theorem.)

Instead of drawing a figure, let us look at Fig. 1 again. OP is a straight line meeting the straight line XOX^1 at O and forming two adjacent angles, XOP and X^1OP.

It is required to prove that $\angle XOP + \angle X^1OP = 2$ right angles $= 180°$.

Proof.—We know that OP and OX^1 are positions of OX rotated round O. Obviously OX is rotated through 90° when it is in the position OY, and through another 90° when it is in the position OX^1, *i.e.* when X reaches X^1 OX has been rotated through 180° or 2 right angles. Hence the angles $XOP + X^1OP = 180°$.

Or again, a glance at the figure will show that

$\angle XOP = a$ and $\angle X^1OP = \beta + a + \beta$;

$$\therefore \quad \angle XOP + \angle X^1OP = a + \beta + a + \beta$$
$$= 2a + 2\beta$$
$$= 2(a + \beta).$$

But we saw that $a + \beta = 90°$;

$$\therefore \quad \angle XOP + \angle X^1OP = 2 \times 90°$$
$$= 180°$$
$$= 2 \text{ right angles.}$$

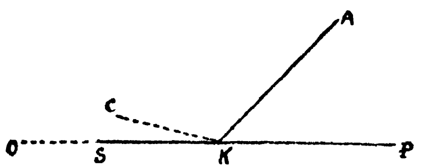
Corollary.—In Fig. 1 we see that the sum of the consecutive angles made by straight lines which meet at a point is equal to four right angles, *i.e.* 360°.

For OX in one complete revolution passes through 360°, *i.e.* four right angles. The same figure also shows that when two straight lines intersect, the sum of the four angles formed is equal to four right angles.

Note.—In Fig. 1 we have two angles, a and β, whose sum is a right angle. These angles are said to be *complementary* to each other: a is the *complement* of β; β is the *complement* of a.

In the same figure the angle a and the angle X^1OP make up 2 right angles: these angles are said to be *supplementary*: the angle a is the *supplement* of $\angle XO^1P$, and *vice versa.*

If, at a point in a straight line, two other straight lines on opposite sides of it make the adjacent angles equal to two right angles, these two straight lines together form one straight line. (Euclid, I, 14.—A Theorem.)



AK is the straight line. KS and KP are two straight lines meeting AK in K and making the adjacent angles SKA and PKA equal to 2 right angles.

It is required to prove that KS and KP are in the same straight line.

Proof.—Suppose they are not in the same straight line. Produce PK to C; then by supposition PKC is a straight line. Hence by Euclid, I, 13,

$$\angle PKA + \angle AKC = 2 \text{ right angles.}$$

But $\quad \angle PKA + \angle SKA = 2$ right angles;

$$\therefore \quad \angle PKA + \angle AKC = \angle PKA + \angle SKA.$$

Subtract $\angle PKA$ from each side of the equation, and $\angle AKC = \angle SKA$.

Now $\angle AKC$ is a part of $\angle SKA$, therefore it cannot be equal to $\angle SKA$. KC cannot therefore be in the same straight line with KP.

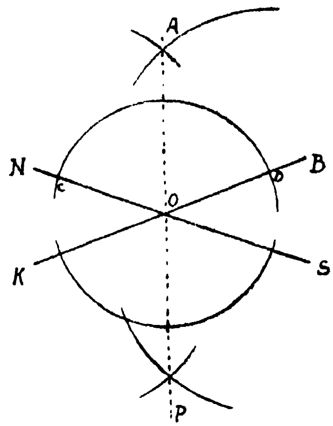
Produce PK to O. Then $\angle PKA + \angle AKO = 2$ right angles $= \angle AKS + \angle PKA$;

$$\therefore \quad \angle AKO = \angle AKS.$$

Hence KS and KO are in the same straight line. But KO is the produced part of KP, Therefore KS and KP are in the same straight line.

This theorem is the converse of Euclid, I, 13.

If two straight lines cut one another, the vertically opposite angles are equal. (Euclid, I, 15.—A Theorem.)



Let NS and BK be two straight lines intersecting at O. It is required to prove that the angle NOB is equal to the vertically opposite angle KOS, and that the angle NOK is equal to the vertically opposite angle BOS.

Proof.—Since OB is a straight line standing on the straight line NOS, $\angle BON + \angle BOS = 2$ right angles. (Euclid, I, 13.)

Again, since NO is a straight line standing on the straight line KOB, $\angle NOB + \angle NOK = 2$ right angles.

$$\therefore \quad \angle BON + \angle BOS = \angle NOB + \angle NOK.$$

Subtract the common angle BON (or NOB) and $\angle BOS = \angle NOK$, its vertically opposite angle.

Similarly $\angle BON = \angle KOS$.

Proof by Rotation.—Suppose KOB originally lies along NOS. To reach the position in the figure, KOB must be rotated about the fixed point O (*cf.* a pair of scissors). Since KOB is straight, the arm OK will move through the same angle as the arm OB.

Hence $\angle$BOS = $\angle$NOK.

Exercise on Euclid, I, 15.—Let AO be a straight line bisecting $\angle$NOB, *i.e.* dividing it into two equal angles, AON and AOB. Let AO be produced to P. Prove that OP bisects the angle KOS.

Proof.—AOP and NOS are straight lines intersecting; $\therefore$ $\angle$AON = vertically opposite $\angle$SOP.

Again AOP and KOB are straight lines intersecting; $\therefore$ $\angle$AOB = $\angle$KOP.

But by construction $\angle$AOB = $\angle$AON, which was proved equal to $\angle$SOP; $\therefore$ $\angle$KOP = $\angle$SOP; hence $\angle$KOS is bisected by OP.

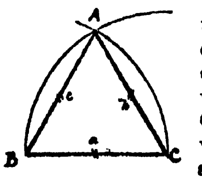
Note.—The $\angle$NOB was bisected in the following way: O was taken as centre, and an arc of any radius was drawn to cut ON and OB at C and D. With C as centre and any radius, an arc was drawn, and with D as centre and the same radius, another arc was made to cut the former. The point of intersection A was joined to AO. AO is the bisector of $\angle$NOB.

Triangles

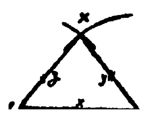
A *Triangle* is a plane figure bounded by three straight lines. When all its angles are equal it is said to be *equiangular;* when its sides are all equal, it is said to be *equilateral.*

An *isosceles triangle* is a triangle having two sides equal. A *scalene triangle* has all its sides unequal.

One side of a triangle is called the *base*, and, as a general rule, the side nearest the bottom of the page is taken as the base. The angular point opposite to the base is the *vertex.* If the vertex is marked with capital A the base is marked with small *a*.



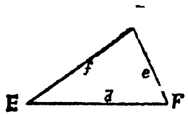
ABC is an equilateral triangle: the base BC, or *a*, was first drawn, then with centre B, radius BC, an arc was drawn; and with centre C, radius CB, another arc was drawn to cut the first arc in A. A and C, A and B were joined. The sides of this triangle are all equal, for BC = BA, being radii of same circle, and CB = CA, being radii of same circle. Hence AB = BC = CA.



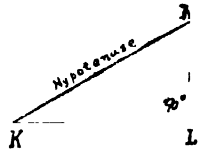
XYZ is an isosceles triangle, having the side XY = side XZ.

DEF is a scalene triangle; its sides are all unequal.

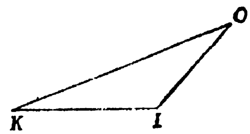
When each of the angles of a triangle is acute (*i.e.* less than a right angle), the triangle is said to be an acute-angled triangle. The $\triangle$s ABC, XYZ, and DEF are all acute-angled.



When one angle of a triangle is a right angle, the triangle is said to be a right-angled triangle. The side opposite to

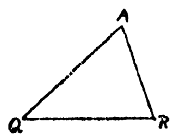


the right angle is known as the hypotenuse. The $\triangle$NLK is a right-angled triangle, the angle NLK being 90°. KN is the hypotenuse of the triangle.



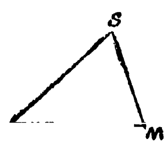
When one angle is obtuse (*i.e.* greater than a right angle) the triangle is called an obtuse-angled triangle, *e.g.* $\triangle$OLK, where $\angle$OLK is greater than 90°.

Superposition of Triangles, &c.—If one geometrical figure, being *superposed* or placed on another, exactly coincide with that other, the two figures are said to be *congruent* or *equal in all respects.*



Consider the $\triangle$s ARQ and SMK.

(1) Suppose all we know about them is that AQ = SK. Can we prove them to be congruent? Lift $\triangle$ARQ and place it so that A lies on S and AQ along SK. Since AQ = SK, the point Q will lie on (coincide with) the point K. But we can prove nothing further. We cannot say that R will fall on M, because we do not know anything about R's position.



(2) Suppose we know that AQ = SK and AR = SM. Superpose $\triangle$AQR on $\triangle$SKM so that AQ coincides with SK. Are we sure that AR will coincide with SM? We are not: we do not know the size of the angle A. If we knew that $\angle$A = $\angle$S, AR would coincide with SM, and since AR = SM, the point R would coincide with the point M. And since Q coincides with K and R with M, the straight line QR must coin-

cide with the straight line KM. We have just proved an important theorem: *If two triangles have two sides of the one equal to two sides of the other each to each, and the angle included by these sides equal, then the triangles are congruent,* (Euclid, I, 4.)

In $\triangle$s ARQ and SMK, if AQ = SK
AR = SM
included $\triangle\ \angle$A = included $\angle$S
then $\triangle$ARQ $\cong$ $\triangle$SMK
i.e. QR = KM, $\angle$Q = $\angle$K, $\angle$R = $\angle$M.

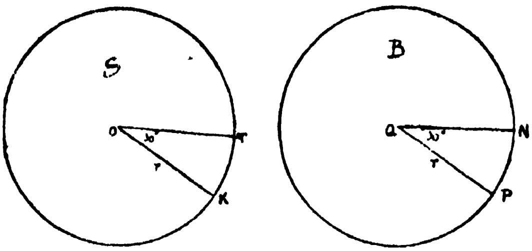
Note.—The sign for "is congruent to" is $\cong$

(3) In $\triangle$s ARQ and SKM, suppose we are told that AQ = SK, AR = SM, and QR = KM. Are they congruent?

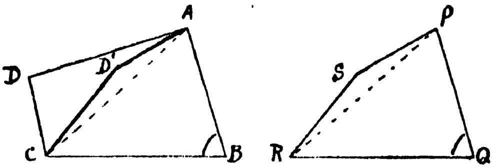
Superpose $\triangle$ARQ on $\triangle$SMK, so that AQ coincides with SK. We do not know the size of $\angle$A, and we therefore cannot tell whether AR lies along SM. Similarly we cannot tell whether QR lies along KM, because we do not know whether $\angle$Q = $\angle$K. We cannot therefore say that the $\triangle$s AQR and SKM are congruent.

(4) Suppose we know that AR = SM and $\angle$ARQ = $\angle$SMK. Can we say the $\triangle$s are congruent? Apply $\triangle$AQR to $\triangle$SKM, so that A coincides with S and AR lies along SM. Since AR = SM, R will coincide with M; hence AR coincides with SM. Now since $\angle$R = $\angle$M, RQ will lie along MK; but we cannot say that Q will coincide with K, for we do not know whether or not QR = KM. In this case we cannot say the triangles are congruent.

(5) Suppose we have given AQ = SK, QR = KM, and $\angle$R = $\angle$M, can we prove the triangles congruent? Apply $\triangle$ARQ to $\triangle$SMK, so that AQ coincides with SK. We cannot tell if QR will coincide with KM, because we do not know whether $\angle$Q = $\angle$K. Similarly, because we are not told that $\angle$A = $\angle$S, we cannot definitely say that AR coincides with SM. Hence we cannot prove the $\triangle$s congruent.



Superposition of Circles.—Let the circles S and B have the same radius r. If S be lifted and placed so that its centre O lies on the centre Q of circle B, and the radius OK lies along radius QP, then K will coincide with P, since OK = QP = r. In S let the radius OK be rotated through an angle of 30°, so that it takes up position OT; and in B let QP be rotated through the same angle, so that it takes up position QN. Then OK = OT = QP = QN = r. If we apply S to B, so that OK coincides with QP, OT will lie along QN, since $\angle$O = $\angle$Q = 30°; and since OT = QN, the point T will coincide with the point N. Hence the arc KT will coincide with the arc PN. By moving the radii round through equal angles, we find that the path traversed by K coincides with the path traversed by P. Hence circle S = circle B.



Superposition of Quadrilaterals.—*Note.*—A *Quadrilateral* is a four-sided figure. Let ABCD and PQRS be two quadrilaterals, having

CB = RQ
AB = PQ
$\angle$B = $\angle$Q.

Let us prove the quadrilaterals congruent.
Join AC and PR.

Cut out $\triangle$ABC and apply it to $\triangle$PQR. It will coincide with it, because

Since AB = PQ
BC = QK
included $\angle$B = included Q
$\triangle$ABC $\cong$ $\triangle$PQR.
(Euclid, I, 4.)

Cut out the remainder of the quadrilateral ABCD, viz. $\triangle$ ACD. Can we apply it to $\triangle$ PSR? We cannot, for we know nothing about either $\triangle$, except that AC = PR. Hence we cannot say that ABCD $\cong$ PQRS.

Suppose we have given

AB = PQ
BC = QR
$\angle$B = $\angle$Q
$\angle$D^{1}AB = $\angle$SPQ
AD^1 = PS.

As before, $\triangle$ABC $\cong$ $\triangle$PQR.

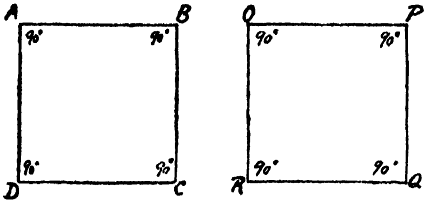
Apply $\triangle$ ACD^1 to $\triangle$ PRS. Since AB coincides with PQ and $\angle$D^{1}AB = $\angle$SPQ, AD^1 lies along PS. But AD^1 = PS, $\therefore$ D^1 coincides with S; and because C coincides with R, CD^1 coincides with RS. Hence quadrilateral ABCD^1 $\cong$ quadrilateral PQRS.

Superposition of Squares.—(For definition of a square see p. 501.)

Let ABCD and OPQR be two squares having the side AB = the side OP.

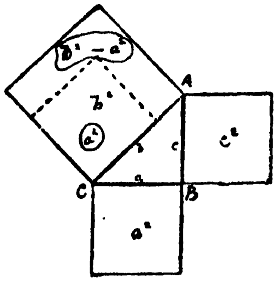
Note.—In a square (1) the four sides are equal, (2) the opposite sides are parallel, (3) each angle is a right angle.

Since AB = OP, AB = OP = BC = PQ = DC = RQ = AD = QR. Apply ABCD to OPQR, so



that AB coincides with OP. Then, because ∠B = ∠P, BC will lie along PQ; and because BC = PQ, C will coincide with Q, and so on. Hence ABCD coincides with OPQR, *i.e.* ABCD ≅ OPQR.

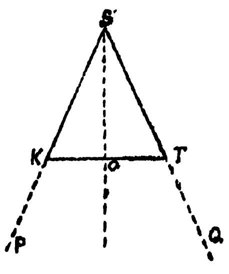
Practical Experiment.—Draw a △ ABC having the ∠B = 90°. Then AC is the hypotenuse of the right-angled triangle ABC.



Prove by measurement that the square on AC is equal to the sum of the squares on AB and BC, *i.e.* prove $b^2 = a^2 + c^2$.

On each side describe a square. Cut out a^2 and lay it on b^2, then cut c^2 into parts that will fit into $b^2 - a^2$. It will be found that $a^2 + c^2$ exactly cover b^2.

The angles at the base of an isosceles triangle are equal. (Euclid, I, 5.—A Theorem.)



Let SKT be an isosceles triangle having the side SK equal to the side ST.

It is required to prove that ∠SKT = ∠STK.

Bisect the ∠S, and let the bisector meet the base KT at O.

Proof.—We have two triangles SOK and SOT having

SK = ST

SO = SO (or SO is common to both triangles)

included ∠KSO = included ∠TSO, because OS bisects ∠KST

∴ △KSO = △TSO (Euclid, I, 4)

Hence ∠SKO = ∠STO.

Another method of proving this theorem is to fold the △SKO about SO. Then SK lies along ST, since ∠KSO = ∠TSO, and K lies on T since KS = TS. And because K falls on T, OK will coincide with OT, and the ∠SKO will coincide with the ∠STO. Hence ∠SKO = ∠STO.

If the sides SK and ST be produced beyond the base KT, the exterior angle TKP is equal to the exterior angle KTQ.

For the straight line SP is met by the straight line KT at K;

∴ ∠TKS + ∠TKP = 180°.

Similarly ∠KTS + ∠KTQ = 180°;

∴ ∠TKS + ∠TKP = ∠KTS + ∠KTQ.

But ∠TKS was proved to be equal to ∠KTS;

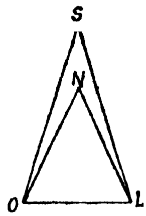
∴ ∠TKP = ∠KTQ.

Thus the exterior angles of an isosceles triangle whose equal sides have been produced are equal to one another. We can prove this in another way. Let ∠SKT = ∠STK = a. Then exterior angle PKT = 180° − a = ∠QTK. This proof depends on Euclid, I, 13.

Exercises.—(1) *Prove that if a triangle is equilateral it is also equiangular.*

An equilateral triangle is an isosceles triangle, hence the angles at the base are equal. But if the triangle be turned round, it will be seen that any side may be taken as the base.

(2) If SOL and NOL be two isosceles triangles on the same base OL, prove that the angle SON is equal to the angle SLN.



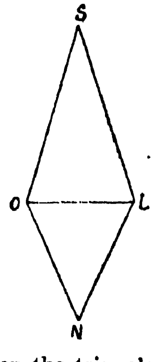
Case I.—When the triangles are on the same side of OL.

∠SOL = ∠SLO (Euclid, I, 5)

and ∠NOL = ∠NLO („)

∴ ∠SOL − ∠NOL = ∠SLO − ∠NLO

i.e. ∠SON = ∠SLN.



Case II.—When the triangles are on opposite sides of OL.

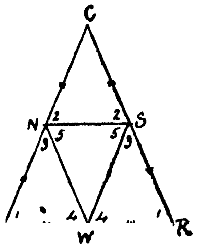
∠SOL = ∠SLO (Euclid, I, 5)

∠NOL = ∠NLO („)

∴ ∠SOL + ∠NOL = ∠SLO + ∠NLO

i.e. ∠SON = ∠SLN.

(3) Let us try experiments with the isosceles triangle CPR. Find the mid-points of the sides



and join these points, thus forming the $\triangle$NSW. In all cases the student should mark on his figure the straight lines and angles that are equal.

In the $\triangle$CPR, CP = CR,

$\therefore \frac{1}{2}$CP = $\frac{1}{2}$CR

i.e. CN or NP = CS or SR.

Since CN = CS, $\triangle$CNS is isosceles,

$\therefore \angle$CNS = $\angle$CSN.

Consider the $\triangle$s NPW and SWR.

NP = SR

PW = WR, because each = $\frac{1}{2}$PR

included $\angle$NPW = included $\angle$SRW,

$\therefore \triangle$NPW = $\triangle$SWR (Euclid, I, 4)

hence NW = SW

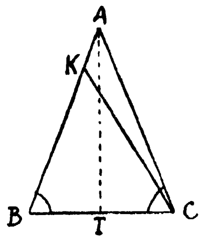
$\angle$PNW = $\angle$RSW

$\angle$PWN = $\angle$RWS.

Again, since NW = SW, the $\triangle$NSW is isosceles;

$\therefore \angle$WNS = $\angle$WSN.

If two angles of a triangle are equal, the sides opposite to the equal angles are equal. (Euclid, I, 6.—A Theorem.)



In the $\triangle$ABC let $\angle$ABC = $\angle$ACB.

It is required to prove that AC, the side opposite to $\angle$ABC, is equal to AB, the side opposite to $\angle$ACB.

Proof.—If AB and AC are unequal, one must be greater than the other. Suppose AB to be greater than AC, and from it cut off BK = AC. Join KC.

In $\triangle$s KBC and ABC

BK = AC

BC is common to both $\triangle$s

included $\angle$KBC = included $\angle$ACB;

$\therefore$ $\triangle$KBC = $\triangle$ABC (Euclid, I, 4).

That is, the part is equal to the whole, which is impossible. $\therefore$ AB is not unequal to AC, *i.e.*

AB = BC.

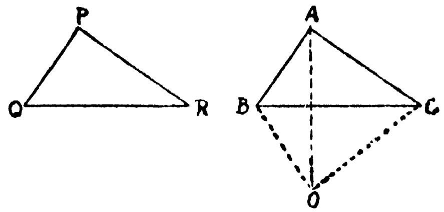
Note.—This kind of proof is known as Reductio ad Absurdum.

The above theorem may be proved by bisecting BC and joining the mid-point T to A. If the $\triangle$ABT is folded over the straight line AT, the side TB will lie along the side TC; and since TB = TC, the point B will coincide with the point C. And since $\angle$ABT = $\angle$ACT, the side BA will lie along the side CA. Hence $\triangle$ABT is congruent to the $\triangle$ATC. It follows that

AB = AC.

This proof also shows that the straight line joining the vertex to the mid-point of the base of an isosceles triangle is perpendicular, for $\angle$ATB = $\angle$ATC = 90°; and that this straight line bisects the vertical angle, since $\angle$BAT = $\angle$CAT, the triangles ABT and ACT being congruent.

If two triangles have the three sides of the one equal to the three sides of the other, they are congruent. (Euclid, I, 8.—A Theorem.)



Let PQR and ABC be two triangles having

PQ = AB
QR = BC
PR = AC

It is required to prove that $\triangle$PQR = $\triangle$ABC.

Case I.—When triangles are acute-angled.

Proof.—Imagine $\triangle$PQR to be lifted and placed so that QR coincides with BC. Let $\triangle$PQR be turned about BC until it lies in the position of $\triangle$BCO. P's new position is at O. Join AO.

Then, because BA = BO, $\angle$BAO = $\angle$BOA.

And because CA = CO, $\angle$CAO = $\angle$COA;

$\therefore \angle$BAO + $\angle$CAO = $\angle$BOA + $\angle$COA

that is, $\angle$BAC = $\angle$BOC = $\angle$P.

Hence in $\triangle$s PQR and ABC

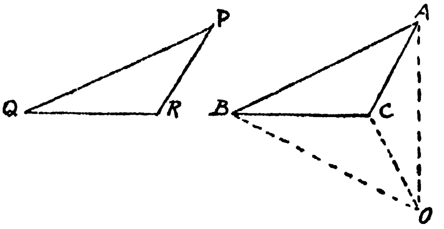
PQ = AB

PR = AC

included $\angle$P = included $\angle$A

$\therefore \triangle$PQR $\cong \triangle$ABC (Euc., I, 4).

Case II.—When the triangles are obtuse-angled.



In this case $AB = BO$

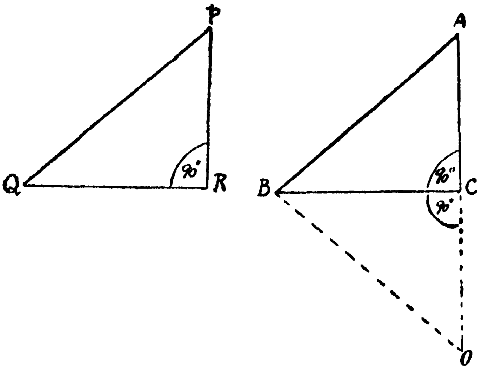
$\therefore \angle BAO = \angle BOA$

and $AC = OC$

$\therefore \angle CAO = \angle COA$

hence $\angle BAO - \angle CAO = \angle BOA - \angle COA$

i.e. $\angle BAC = \angle BOC$, etc.



Case III.—When the triangles are right-angled.

$\angle ACB = \angle PRQ = \angle BCO = 90°$.

Hence ACO is a straight line.

In $\triangle$s ABC and BCO

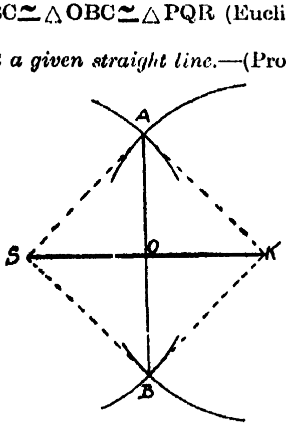
$AC = CO$

BC is common

included $\angle ACB =$ included $\angle OCB$

$\therefore \quad \triangle ABC \cong \triangle OBC \cong \triangle PQR$ (Euclid, I, 4).

To bisect a given straight line.—(Problem 1.)



Let SK be the line to be bisected.

Construction.—With centre S, and any radius greater than $\frac{1}{2}$SK, draw two arcs, one on each side of SK, and with centre K and the same radius draw two arcs cutting the former arcs in A and B. Join AB, and let AB cut SK in O. O is the mid-point of SK.

Proof.—Join AS, AK, BS, BK. These are all equal, being radii of equal circles.

In the $\triangle$s ASB and AKB

$AS = AK$

$BS = BK$

$AB = AB$

$\therefore \quad \triangle ASB = \triangle AKB$ (Euclid, I, 8)

$\therefore \quad \angle SAB = \angle KAB$.

In the $\triangle$s ASO and AKO

$SA = KA$

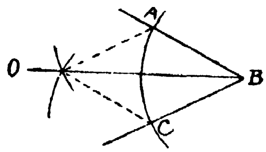
$AO = AO$

included $\triangle SAO =$ included $\triangle KAO$

$\therefore \quad \triangle ASO = \triangle AKO$ (Euclid, I, 4)

$\therefore$ $SO = OK$, that is, SK is bisected in O.

To bisect a given angle.—(Problem 2.)



Let ABC be the angle to be bisected.

Construction.—With centre B, and any radius, draw an arc cutting the arms of the angle at A and C. With centres A and C, and any radius, draw two arcs intersecting at O. Join OB. OB bisects $\angle ABC$.

Proof.—Join AO and OC.

In $\triangle$s AOB and COB

$AO = OC$ being equal radii

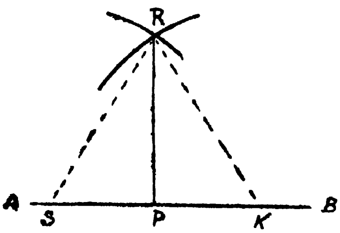
$AB = BC$,,

$OB = OB$,,

$\therefore \quad \triangle AOB = \triangle COB$ (Euclid, I, 8)

Hence $\angle ABO = \angle CBO$, *i.e.* $\angle ABC$ is bisected by the straight line OB.

To draw a straight line perpendicular to a given straight line from a given point within it.—(Problem 3.)



Let AB be the straight line and P the point in it from which the perpendicular (or normal) is to be drawn.

Construction.—With centre P and any radius, cut off two equal parts PS and PK from AB.

With centres S and K and any radius, draw two arcs intersecting at R. Join RP.

RP is normal to AD.

Proof.—Join RS and RK.

In $\triangle$s RSP and RKP

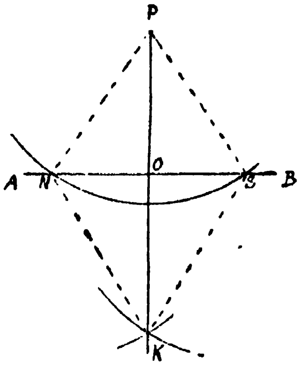
RS = RK, being equal radii
RP is common
PS = PK, being equal radii

$\therefore$ $\triangle RSP = \triangle RKP$ (Euclid, I, 8)

Hence $\angle RPS = \angle RPK$

and these being adjacent angles, each is a right angle, that is, RP is perpendicular to AB.

To draw a straight line perpendicular to a given straight line from a given external point.—(Problem 4.)



Let AB be the straight line and P the external point from which the normal is to be drawn.

Construction.—With centre P and any radius, draw an arc cutting AB in N and S. With centres N and S and any radius, draw two arcs intersecting at K. Join PK, cutting AB in O. OP is the normal required.

Proof.—Join PN, PS, KN, KS.

In $\triangle$s PNK and PSK

PN = PS
NK = SK
PK is common

$\therefore$ $\triangle PNK = \triangle PSK$ (Euclid, I, 8)

$\therefore$ $\angle NPK = \angle SPK$.

Again in $\triangle$s PNO and POS

PN = PS
PO is common

included $\angle NPO$ = included $\angle SPO$

$\therefore$ $\triangle PNO = \triangle POS$ (Euclid, I, 4)

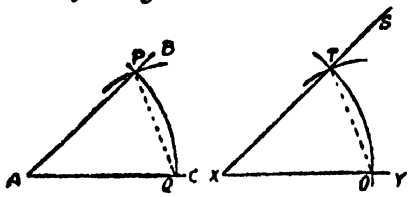
$\therefore$ $\angle PON = \angle POS$, and as these are adjacent angles each is a right angle,

Hence PO is perpendicular to AB.

To construct an angle equal to a given angle.—(Problem 5.)

Let BAC be the given angle.

Draw any straight line XY. With centre A



and any radius, draw an arc, cutting AC in Q and AB in P; and with centre X and the same radius, draw an arc cutting XY in O. With centre O and radius QP, draw an arc cutting the former arc in T. Join XT, and produce it to, say, S.

Then $\angle SXY = \angle BAC$.

Proof.—Join PQ and TO.

In $\triangle$s PAQ and TXO

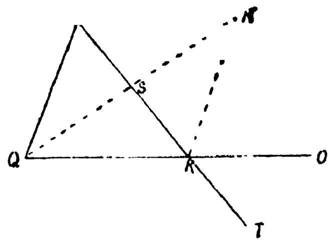
AQ = XO being radii of equal circles
AP = XT ,, ,,
QP = OT by construction

$\therefore$ $\triangle PAQ = \triangle TXO$ (Euclid, I, 8)

$\therefore$ $\angle A = \angle X$

i.e. $\angle BAC = \angle SXY$.

If one side of a triangle be produced, then the exterior angle is greater than either of the interior opposite angles.—(Euclid, I, 16.—Theorem.)



Let the $\triangle PQR$ have the side QR produced to O.

It is required to prove that exterior $\angle PRO$ is greater than either of the interior opposite angles PQR and QPR.

Find S the mid-point of PR; join QS, and produce it to K so that QS = SK. Join KR.

Proof.—In $\triangle$s PSQ and KSR

PS = SR
QS = SK

included $\angle PSQ$ = included $\angle KSR$, since they are vertically opposite

$\triangle PSQ = \triangle KSR$ (Euclid, I, 4)

hence $\angle P = \angle SRK$.

But $\angle PRO > \angle SRK$

$\therefore$ $\angle PRO > \angle P$.

The sign > means "is greater than."

Again, if PR be produced to T the exterior $\angle QRT$ is greater than the interior opposite $\angle PQR$. But $\angle QRT$ = vertically opposite $\angle PRO$.

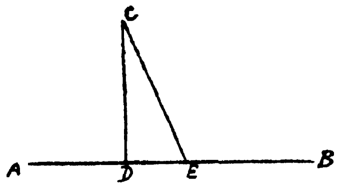
Hence $\angle PRO$ is greater than $\angle PQR$.

From this theorem it follows that (1) *any two angles of a triangle are less than* 180°. For in above figure $\angle PRO > \angle PQR$. To each add $\angle PRQ$. Then $\angle PRO + \angle PRQ > \angle PQR + \angle PRQ$.

But $\quad \angle PRO + \angle PQR = 180°$.

$\therefore \quad 180° > \angle PQR + \angle PRQ$.

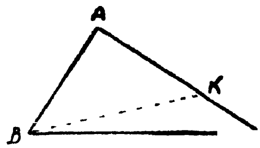
(2) *Only one normal can be drawn from an external point to a straight line.*



Let CD be a normal drawn from the point C to the straight line AB and suppose CE is another normal, then $\angle CDE = \angle CED = 90°$. But by Euclid, I, 16, exterior $\angle CEB$ of $\triangle CED$ $>$ interior opposite $\angle CDE$. Hence since $\angle CDE = 90°$, $\angle CEB > 90°$.

$\therefore$ CE is not perpendicular to AB, and no other normal can be drawn from C to AB than CD.

If one side of a triangle is greater than another, the angle opposite to the greater side is greater than the angle opposite to the less. (Euclid, I, 18.—A Theorem.)



In the $\triangle ABC$ let AC be greater than AB. It is required to prove that $\angle ABC$, opposite to AC, is greater than $\angle ACB$, opposite to AB.

Proof.—From AC cut off AK = AB.

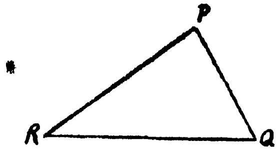
Then $\triangle ABK$ is isosceles ; $\therefore \angle ABK = \angle AKB$.

But $\quad \angle AKB > \angle C$ (Euclid, I, 16)

$\therefore \quad \angle ABK > \angle C$.

Since $\angle ABK$ is greater than $\angle C$, $\angle ABC$, which contains $\angle ABK$, is much greater than $\angle C$.

If one angle of a triangle is greater than another, the side opposite to the greater angle is greater than the side opposite to the less. (Euclid, I, 19.—A Theorem.)



This is the *converse* of Euclid, I, 18.

Let PQR be a $\triangle$ having $\angle Q > \angle R$.

It is required to prove that PR is greater than PQ.

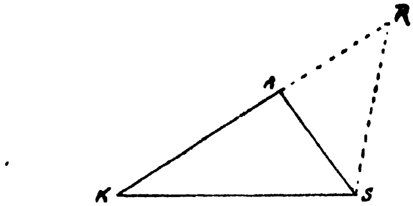
Proof.—If PR is not greater than PQ, suppose PR = PQ. Then $\angle R = \angle Q$ (Euclid, I, 5). But $\angle Q > \angle R$, hence PR is not equal to PQ.

Suppose PR to be less than PQ. Then $\angle Q$ is less than $\angle R$ (Euclid, I, 18). But $\angle Q$ is given as being greater than $\angle K$.

$\therefore \quad$ PR is not less than PQ.

Hence PR must be greater than PQ.

Any two sides of a triangle are greater than the third side. (Euclid, I, 20.—A Theorem.)



Let ASK be a triangle. It is required to prove that AS + AK > SK.

Let SK be the greatest side. Produce KA to R, making AR = AS. Join RS. Then KR is greater than KS.

Proof.—Since AR = AS, $\angle ARS = \angle ASR$.

But $\angle RSK > \angle RSA$, its part.

$\therefore$ in $\triangle RSK$, $\angle RSK > \angle KRS$.

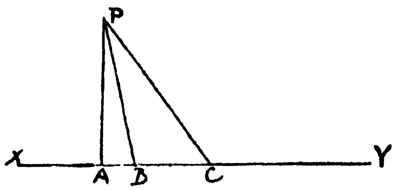
Hence side opposite $\angle RSK$ > side opposite $\angle KRS$. *i.e.* KR > KS

But $\quad KR = KA + AR$

$\quad = KA + AS$

$\therefore \quad KA + AS > KS$.

Exercise.—Prove that the normal is the shortest line drawn from a given point to a given straight line.



Let PA be a normal drawn from a point P to the straight line XY, and let PB and PC be other straight lines from P to XY.

Since $\angle PAB = 90°$, $\angle PBA$ is less than 90°, for $\triangle PAB$ cannot have two angles whose sum is two right angles.

Hence $\quad$ PB > PA (Euclid, I, 19).

Similarly $\quad$ PC > PA.

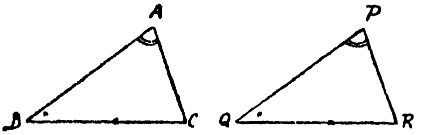
Identical Equality of Triangles.—We already know that two triangles are congruent

(1) When 2 sides and included angle of the one = 2 sides and included angle of the other (Euclid, I, 4).

(2) When the 3 sides of one = 3 sides of other (Euclid, I, 8).

We now proceed to another case.

If two triangles have two angles of one equal to two angles of the other, each to each, and any side of the one equal to the corresponding side of the other, the triangles are congruent. (Euclid, I, 26.—A Theorem.)



Let ABC and PQR be two triangles having $\angle A = \angle P$, $\angle B = \angle Q$, side BC = side QR.

It is required to prove that $\triangle ABC = \triangle PQR$.

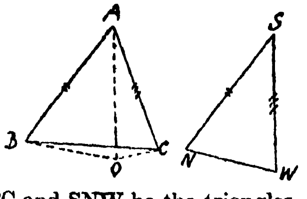
Proof.—$\angle A + \angle B + \angle C = 180°$
$= \angle P + \angle Q + \angle R$
$\therefore \angle C = \angle R$.

Apply $\triangle ABC$ to $\triangle PQR$, so that B falls on Q and BC along QR. Since BC = QR, C coincides with R.

Since $\angle B = \angle Q$, BA will lie along QP; and since $\angle C = \angle R$, CA will lie along RP. And the point A, which is in BA and in CA, must fall on P, where OP and RP join.

Hence $\triangle ABC \simeq PQR$
i.e. AB = PQ
AC = PR
area of $\triangle ABC$ = area of $\triangle PQR$.

If two triangles have two sides of the one equal to two sides of the other, each to each, but the angle included by the two sides of the one greater than the angle included by the corresponding sides of the other, then the base of that which has the greater angle is greater than the base of the other. (Euclid, I, 24.—A Theorem.)



Let ABC and SNW be the triangles, having

AB = SN
AC = SW
$\angle BAC > \angle S$

It is required to prove BC greater than NW.

Proof.—At A make $\angle BAO = \angle S$, and make AO = SW. Join BO and OC.

Then $\triangle ABO = \triangle SNW$ (Euclid, I, 4).

In $\triangle ACO$, AO = AC

$\therefore$ $\angle AOC = \angle ACO$ (Euclid, I, 5)
But $\angle ACO >$ its part $\angle BCO$
$\therefore$ $\angle AOC > \angle BCO$

Hence $\angle BOC$ is much greater than $\angle BCO$.

In $\triangle BOC$ the $\angle BOC > \angle BCO$, $\therefore$ BC, the side opposite $\angle BOC >$ BO, the side opposite to $\angle BCO$.

But BO = NW
Hence BC > NW.

We can now write down the conditions of identity for two triangles.

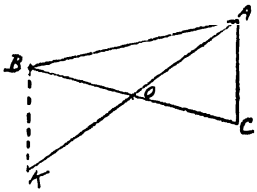
Two triangles are identical when the following parts of one are equal to the corresponding parts of the other.

(1) Two sides and included angle (Euclid, I, 4).
(2) Three sides (Euclid, I, 8).
(3) Two angles and a side (Euclid, I, 26).

Note.—Two triangles are not necessarily equal if their angles are equal. Prove this by drawing two triangles, one inside the other.

Exercises on Angles and Triangles.—(1) *In any triangle the sum of any two sides is greater than twice the median which bisects the remaining side.*

Note.—A *median* is a straight line joining a vertex of a triangle with the mid-point of the opposite side.

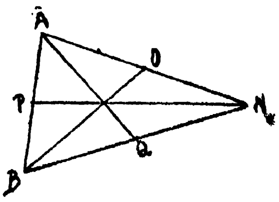


Let ABC be a triangle. Let the median AO be produced to K, so that AK = 2AO. Then AB + AC > AK.

Proof.—Join BK. In $\triangle$s AOC and OBK
AO = OK
OB = OC
included $\angle AOC$ = included $\angle BOK$, vertically opposite
$\therefore$ $\triangle AOC = \triangle OBK$ (Euclid, I. 4).
Hence AC = BK.
But AB + BK > AK (Euclid, I, 20)
$\therefore$ AB + AC > AK, *i.e.* twice the median AO.

(2) *In any triangle the perimeter is greater than the sum of the medians.*

Note.—The perimeter of a triangle is the sum of its sides.



Let $\triangle ABN$ have the medians AQ, BO, NP. Then AB + BN + NA > AQ + BO + PN.

By the previous exercise,

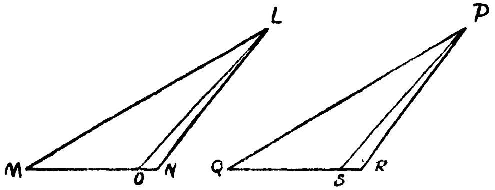
$$AB+AN>2AQ$$

so $$AB+BN>2BO$$

and $$BN+NA>2NP.$$

Add, and $2AB+2BN+2NA>2AQ+2BO+2NP$.
Cancel by 2, and $AB+BN+NA>AQ+BO+NP$.

(3) *In the triangles LMN and PQR the sides LM, LN, and the angle MLN are respectively equal to the sides PQ, PR, and the angle QPR; O is a point in MN, and S is a point in QR such that MO is equal to QS. Prove that LO is equal to PS.* (L. C. Lower, 1912.)



Here we are given two sides and included angle of one triangle equal to two sides and included angle of another triangle. Evidently the solution depends upon Euclid, I, 4.

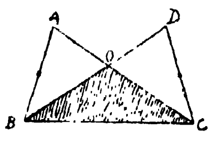
In $\triangle$s LMN and PQR

$$LM=PQ$$
$$LN=PR$$
$$\text{included } \angle MLN = \text{included } \angle QPR$$
$$\therefore \quad \triangle LMN = \triangle PQR \text{ (Euclid, I, 4)}$$
Hence $$\angle M = \angle Q$$

In $\triangle$s LMO and PQS

$$LM=PQ$$
$$MO=QS$$
$$\text{included } \angle M = \text{included } \angle Q$$
$$\therefore \quad \triangle LMO = \triangle PQS \text{ (Euclid, I, 4)}$$
Hence $$LO=PS.$$

(4) *ABC and DBC are two triangles on the same side of BC, such that AB = CD, AC = BD. If AC, BD intersect in O, prove that the triangle AOB, COD are equal in all respects.*
(L. C. Lower, 1911.)



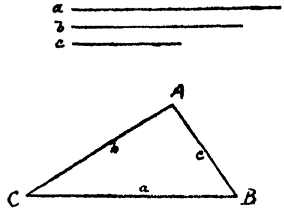
In $\triangle$s ABC and DBC

$$AB=DC$$
$$AC=DC$$
$$BC \text{ is common}$$
$$\triangle ABC = \triangle DBC \text{ (Euclid I, 8).}$$
$$AC=BD$$
Also $$\angle ACB = \angle DBC$$
$$\angle OCB = \angle OBC$$
$$OC=OB$$
Now $$AC=BD$$
$$AC-OC=BD-OB$$
$$AO=DO$$

In $\triangle$s AOB, COD

$$AB=CD \text{ given.}$$
$$OB=OC \text{ proved.}$$
$$AO=DO \quad \text{,,}$$
$$\triangle\text{s are congruent.}$$

Construct a triangle having the three sides given.

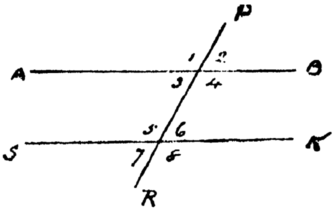


Let a, b, c be the three sides. Draw a straight line $CB=a$. With centre B and radius c draw an arc, and with centre C and radius b draw an arc, cutting the former arc in A. Join AB and AC.

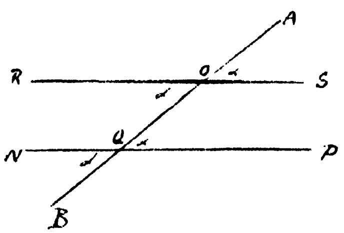
ABC is the required triangle.

Parallels

One straight line is parallel to another in the same plane when the two do not meet however far they are produced at both ends. The best example are the rails of a railway track.



If a pole PR is laid across a railway track whose rails are AB and SK, it forms with the two parallel lines 8 angles. 1, 2, 7, 8 are exterior angles; 3, 4, 5, 6 are interior angles; 3 and 6 are alternate angles. So also 4 and 5 are alternate angles. 6 is known as the interior opposite angle to the exterior angle 2, on the same side of PR.



Consider the straight line AOQB which cuts the straight lines RS and NP, making the exterior $\angle AOS$ equal to the interior opposite $\angle OQP$ on the same side of AB. Call each of the $\angle$s AOS and OQP α Suppose that the point O is fixed, and suppose that RS is folded

back so that it lies along BA. To get RS into its original position we must rotate it about O through an angle a. Similarly NP if folded. back so as so lie on BA would require to be rotated through an angle a so as to take up its original position. In short, RS and NP, if lying along BA, are each rotated through an angle of a, hence they must run in one direction; that is, they are parallel.

The same result is found if we move NP up the line BA, always keeping $\angle AQP = a$. When NP reaches RS it coincides with it, because $\angle AQP$ coincides with $\angle AOB$, because each equals a. Hence NP is parallel to RS.

Again, alternate $\angle ROQ = \angle AOS$, being vertically opposite

$$= \text{alternate } \angle OQP.$$

Hence two straight lines are parallel when the alternate angles made by a straight line cutting them are equal.

Again $\quad \angle AOS + \angle SOQ = 180°$

But $\quad \angle AOS = \angle OQP$

$\therefore \quad \angle OQP + \angle SOQ = 180°.$

Hence two straight lines are parallel when the sum of the interior angles made by a cutting straight line are equal to two right angles.

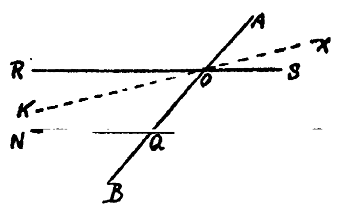
We have just proved Euclid, I, 27 and 28 theorems, which state that, *if a straight line cuts two straight lines so as to make* (1) *the alternate angles equal,* (2) *the exterior angle equal to the interior opposite angle on the same side of the cutting line,* (3) *the sum of the two interior angles on the same side of the cutting line equal to two right angles; then the two straight lines are parallel.*

If a straight line cuts two parallel straight lines it makes

(1) The alternate angles equal.

(2) The exterior angle equal to the interior opposite angle on the same side of the cutting line.

(3) The two interior angles on the same side of the cutting line together equal two right angles. (Euclid, I, 29—Theorem; the converse of above.)



Let AOQB be a straight line cutting two parallel straight lines RS and NP at O and Q.

It is required to prove

$$\angle ROQ = \angle OQP$$
$$\angle AOS = \angle OQP$$
$$\angle SOQ + \angle OQP = 180°.$$

Proof.—(i.) If $\angle ROQ$ is not equal to $\angle OQP$, make $\angle KOQ = \angle OQP$.

$\therefore$ KOX (*i.e.* KO produced) is parallel to NP (Euclid, I, 28.)

But RS is parallel to (ii.) NP.

$\therefore$ KX is parallel to RS, which is impossible, since they meet at a point.

Hence $\angle KOQ$ is not equal to $\angle OQP$.

Thus it can be shown that $\angle ROQ = \angle OQP$.

(ii.) $\quad \angle ROQ = \angle AOS$

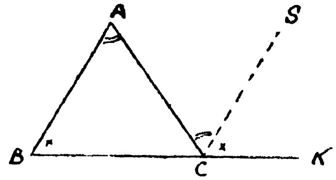
$\therefore \angle AOS = \angle OQP.$

(iii.) $\quad \angle AOS + \angle SOQ = 180°$

but $\angle AOS = OQP$

$\therefore \angle OQP + \angle SOQ = 180°.$

The three angles of a triangle are together equal to two right angles. (Euclid, I, 32.—Theorem.)



Let ABC be the triangle. It is required to prove that $\angle A + \angle B + \angle C = 180°$.

Proof.—Produce the side BC to K. At C draw CS ∥ AB.

Then because AC meets the parallel straight lines AB and CS, the alternate $\angle A$ = alternate $\angle ACS$.

Again, because BK meets the parallels AB and CS, $\angle B = \angle SCK$.

Hence $\angle A + \angle B = \angle ACS + \angle SCK$.

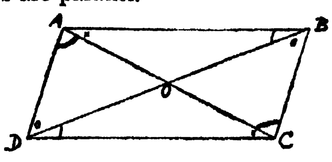
To each side of the equation add $\angle ACB$.

$$\therefore \angle A + \angle B + \angle ACB = \angle ACS + \angle SCK + \angle ACB = 180°.$$

It follows that if two angles of one triangle are together equal to two angles of another triangle, the third angle of the one is equal to the third angle of the other.

The Parallelogram

A *parallelogram* is a quadrilateral whose opposite sides are parallel.



ABCD is a parallelogram, AB being parallel to DC and AD to BC. Draw the diagonals DB and AC and let them intersect at O.

Since AC meets the parallels AB and DC alternate $\angle BAC$ = alternate $\angle ACD$.

Again, since AC meets the parallels AD and BC

alternate $\angle DAC$ = alternate $\angle ACB$.

In $\triangle$s ABC and ADC

$$\angle BAC = \angle ACD$$
$$\angle BCA = \angle DAC$$
AC is common
$$\therefore \triangle ABC = \triangle ADC \text{ (Euclid, I, 26)}$$

The diagonal divides the parallelogram into two equal parts.

Since $\triangle ABC = \triangle ADC$

$$\therefore AB = DC$$
$$\text{and } AD = BC$$

The opposite sides of a parallelogram are equal.

Because $\angle BAC = \angle ACD$

and $\angle DAC = \angle ACB$

then $\angle BAC + \angle DAC = \angle ACD + \angle ACB$

i.e. $\angle DAB = \angle DCB$.

Similarly $\angle ABC = \angle ADC$.

The opposite angles of a parallelogram are equal.

The above proves the theorem, Euclid, I, 24.

The opposite sides and angles of a parallelogram are equal, and each diagonal bisects the parallelogram.

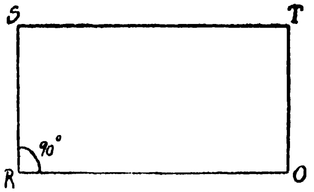
It can be shown that *the diagonals of a parallelogram bisect each other.*

For in $\triangle$s AOD and BOC

$$AD = BC$$
$$\angle ADO = \angle OBC$$
$$\angle DAO = \angle BCO$$
$$\therefore \triangle AOD = \triangle BOC \text{ (Euclid, I, 26)}$$

hence $AO = OC$ and $DO = OB$.

The Rectangle.—A *rectangle* is a parallelogram which has one of its angles a right angle.



Let STOR be a rectangle having $\angle R = 90°$.

Because SR meets the parallels ST and RO

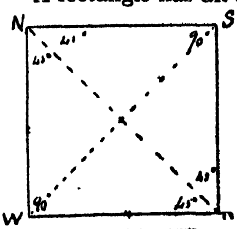
$$\angle S + \angle R = 180° \text{ (Euclid, I, 28)}$$
$$\therefore \quad \angle S = 90°.$$

So also because ST meets the parallels SR and TO,

$$\angle S + \angle T = 180° \text{ (Euclid, I, 28)}$$
$$\therefore \angle T = 90°.$$

Similarly $\angle O = 90°$.

A rectangle has all its angles right.



The Square.—A *square* is a rectangle having two adjacent sides equal.

NSRW is a square having $WN = WR$.

Since a square is a rectangle, all its angles are right angles.

Because $WN = WR$, $\angle WNR = \angle WRN$. (Euclid, I, 5.)

Now in $\triangle NRW$

$$\angle W + \angle WNR + \angle WRN = 180°.$$

But $\angle W = 90°$,

$$\therefore 90° + \angle WNR + \angle WRN = 180°$$
$$\therefore \angle WNR + \angle WRN = 180° - 90° = 90°.$$

But $\angle WNR = \angle WRN$

$$\therefore \quad \text{each} = \frac{90°}{2} = 45°.$$

Since $\angle WNS = 90°$ and $\angle WNR = 45°$, $\angle SNR = 45°$; similarly $\angle SRN = 45°$.

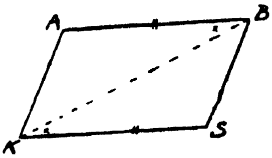
$$\therefore \angle SNR = \angle SRN.$$

Hence $\triangle SNR$ is isosceles

$$\therefore SN = SR.$$

If the other diagonal SW be drawn, it can be shown that $NS = NW$ and $SR = WR$. Hence $NS = SR = RW = NW$. Thus a square is shown to have its four sides equal.

The appearance of a rectangle leads us to guess that the straight lines joining the ends of two equal and parallel straight lines are themselves equal and parallel. (This theorem is Euclid, I, 33.)



Let AB and KS be equal and parallel straight lines. Join AK and BS.

It is required to prove $AK = BS$

and $AK \parallel BS$.

Proof.—Join KB. Because KB meets the parallels AB and KS, alternate $\angle ABK$ = alternate $\angle BKS$.

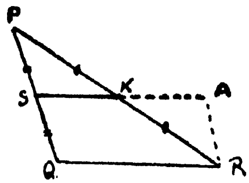
In $\triangle$s ABK and KBS

$$AB = KS$$
BK is common
$$\text{included } \angle ABK = \text{included } \angle BKS$$
$$\therefore \quad \triangle ABK = \triangle BKS \text{ (Euclid, I, 4)}$$
$$\therefore \quad AK = BS$$

and $\angle AKB = \angle KBS$. But these are alternate angles;

$\therefore$ AK is parallel to BS.

The straight line joining the mid-points of two sides of any triangle is parallel to the third side.



In $\triangle PQR$ let S and K be the mid-points of the sides PQ and PR, and let SK be joined.

It is required to prove that SK is parallel to QR.

Proof.—Produce SK to A, so that SK = KA. Join AR.

In $\triangle$s PKS and KAR

SK = KA

PK = KR

included $\angle$PKS = included $\angle$AKR, being vertically opposite

$\therefore$ $\triangle$PSK = $\triangle$KAR (Euclid, I, 4)

Hence $\angle$P = $\angle$KRA, and as these are alternate angles

PQ $\parallel$ AR

and AR = PS = SQ.

Now, because AR is equal and parallel to SQ, SA and QR, which join their ends, must be equal and parallel.

Hence SK is parallel to QR

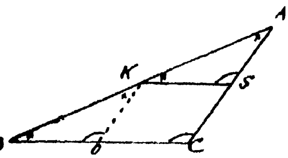
Further, SA = QR

and SA = 2SK

$\therefore$ 2SK = QR

or $SK = \frac{QR}{2}$, *i.e. the straight line joining the mid-points of two sides of a triangle is half the third side.*

The straight line drawn through the mid-point of a side of a triangle, parallel to the base, bisects the remaining side.



Let ABC be a triangle, and let S be the mid-point of AC. Let SK, parallel to the base BC, cut AB in K.

It is required to prove that AB is bisected in K.

Proof.—From K draw KO parallel to AC, and let it meet BC in O.

Then, because AB cuts the parallels KS and BC,

$\angle$AKS = $\angle$ABC.

And since AC meets the parallels KS and BC,

$\angle$ASK = $\angle$ACB = $\angle$KOB, since KO $\parallel$ AC.

Because AB cuts the parallels KO and AC,

$\angle$BKO = $\angle$BAC.

Since KS $\parallel$ OC and KO $\parallel$ SC, KSCO is a parallelogram.

$\therefore$ KO = CS = SA.

In $\triangle$s KOB and ASK

$\angle$B = $\angle$AKS

$\angle$BKO = $\angle$A

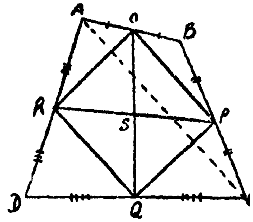
KO = AS

$\therefore$ $\triangle$KOB $\simeq$ $\triangle$ASK (Euclid, I, 26)

$\therefore$ KB = KA

and BO = KS = OC.

Application of above to a Quadrilateral.—Let ABCD be a quadrilateral, and let O, P, Q, R be the mid-points of AB, BC, CD, DA. Join OP, PQ, QR, RO. Draw the diagonal AC.



In $\triangle$ABC, OP, drawn through the mid-points of AB and BC, the sides of $\triangle$ABC, is parallel to AC, the base, and OP = ½AC.

Similarly, in $\triangle$ADC, RQ is parallel to AC and RQ = ½AC.

$\therefore$ RQ = OP.

And RQ and OP, being each parallel to AC, are parallel to each other.

Hence RO and PQ are equal and parallel because they join the ends of the equal and parallel straight lines OP and RQ.

$\therefore$ OPQR is a parallelogram.

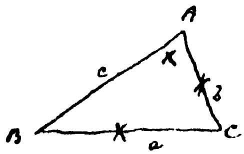
And the diagonals OQ and RP bisect each other.

Hence SO = SQ and SR = SP.

Construction of Triangles

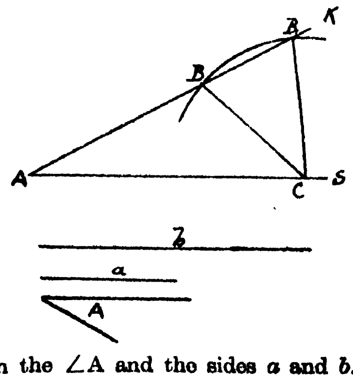
Construct a triangle, having given two sides and an angle opposite to one of them.

In all problems imagine the construction completed and study the figure. The only way to tackle this problem is to draw a rough diagram thus. Suppose ABC to be the completed $\triangle$, and suppose the data given were the sides AC and BC and the $\angle$A opposite to BC.



We may commence with the line BC, but we cannot go any further, for, although we know the length of CA, we do not know what angle AC makes with BC. Clearly we cannot commence our construction from BC.

Try the $\angle$A. We can easily make an angle A, and from one of the arms we can cut off AC, whose length is known. With radius BC and C as centre we can describe an arc, cutting the other arm of the angle at B. Join BC. Now we can make our construction.



Given the $\angle$A and the sides *a* and *b*. Construct the $\triangle$.

Make an angle SAK $=\angle$A. From AS cut off AC $=b$. With centre C and radius a draw an arc, cutting AK in B. Join BC. The $\triangle$ABC is the $\triangle$ required, for it has

$$\angle BAC=\angle A$$
$$AC=b$$
$$BC=a.$$

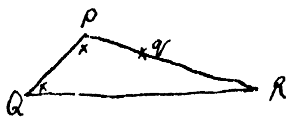
But the arc cuts AK in two places, B and B_1. Join B_1C, and $\triangle AB_1C$ fulfils the conditions also.

For
$$\angle B_1AC=\angle A$$
$$AC=b$$
$$B_1C=a.$$

This double solution is called the AMBIGUOUS CASE.

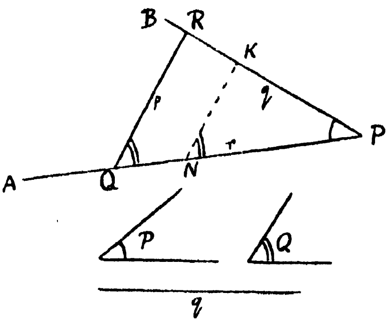
If the radius CB is shortened, CB and CB_1 will come closer together. By continuing the process, we can make CB and CB_1 coincide. Then $\angle$B is a right angle. Therefore if we are given two sides and *a right angle* opposite one of them, there is no ambiguity. This knowledge is very useful.

Construct a triangle, having given the angles P *and* Q *and the side* q.



Draw a rough diagram and mark the parts given. The obvious method of construction is to make an angle equal to P, cut off PR $=q$. But here we stop dead. We do not know the length of PQ or of QR; all we know is the size of $\angle$Q. The construction seems to be impossible, but there is a way out of the difficulty.

Consider the good figure.



Make any angle APB $=\angle$P. On PB set off PR $=q$.

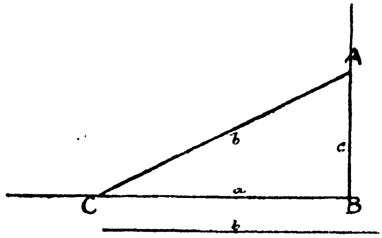
Now we do not know the lengths of RQ and PQ; how, then, are we to fix the point Q?

In PA take any point N and draw NK, making an angle $=\angle$Q with PA. Let NK meet PR in K. Through R draw RQ parallel to KN.

RQP is the required $\triangle$.

Since AQNP is a straight line cutting the parallels QR and NK, the $\angle RQN=\angle KNP=\angle Q$.

Construct a right-angled triangle, having given the hypotenuse and one side.



Let b be the given hypotenuse and c a side of the $\triangle$.

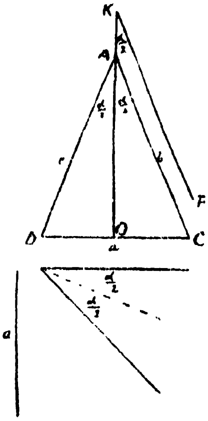
Make an angle B of 90°. On one arm mark off a distance BA $=c$. With centre A, radius b, describe an arc, cutting the other arm in C. Join AC.

ABC is the required $\triangle$.

For hypotenuse AC $=b$, side AB $=c$, and $\angle$ABC opposite AC is a right angle.

Construct an isosceles triangle having given the base and the vertical angle.

Let a be the base and α the vertical angle. Draw a straight line BC $=a$. Bisect BC in O, and at O erect a normal OK. At K make an angle OKP equal to $\frac{1}{2}$ of α. Through C draw CA parallel to PK, and let it meet the normal in A. Join AB. ABC is the required triangle.



Proof.—Because OAK cuts the parallels CA and PK,

$$\angle OAC=\angle AKP \text{ (Euclid, I, 29)}$$
$$=\tfrac{1}{2} \text{ of } \alpha, \text{ i.e. } \frac{\alpha}{2}.$$

In $\triangle$s AOB and AOC

$$OB=OC$$
$$OA \text{ is common}$$
$$\angle AOB=\angle AOC=90°$$
$$\triangle AOB=\triangle AOC \text{ (Euclid, I, 4)}$$

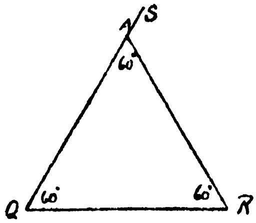
Hence AB $=$ AC, *i.e.* $\triangle$ABC is isosceles

and $\angle BAO=\angle CAO=\frac{\alpha}{2}$

Hence $\angle BAC=\frac{\alpha}{2}+\frac{\alpha}{2}=\alpha$

ABC has AB $=$ AC
$$BC=a$$
$$\angle BAC=\alpha.$$

With a set-square or protractor construct an equilateral triangle having a side of $1\frac{1}{2}$ inches.



Draw a rough equilateral $\triangle$ AQR.

$\angle A = \angle R = \angle Q.$

Now the three angles of a triangle are equal to 180°, hence $\angle A + \angle R + \angle Q = 180°$.

$\therefore \angle A = \angle R = \angle Q = 60°.$

Draw a straight line QR 1·5 inches long. At Q make an angle RQS $= 60°$. From QS cut off QA $=$ QR. Join AR.

AQR is the required triangle.

Proof.—Because QA $=$ QR, $\angle QAR = \angle R$ (Euclid, I, 5)

Now $\angle Q + \angle A + \angle R = 180°$. But $\angle Q = 60°$. Substitute the value for $\angle Q$.

Then $60° + \angle A + \angle R = 180°$

$\therefore \angle A + \angle R = 180° - 60°$

$= 120°.$

Since $\angle A = \angle R$, each is equal to 60°.

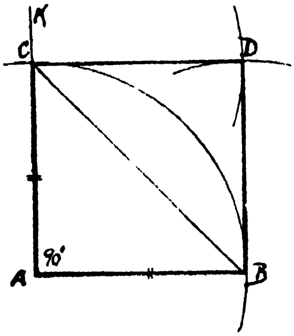
The $\triangle$ is therefore equiangular.

Again, because $\angle Q = \angle R$, AQ $=$ AR (Euclid, I, 6). But AQ $=$ QR, hence AQ $=$ QR $=$ RA.

The $\triangle$ is therefore equilateral.

Construction of Quadrilaterals

Construct a square on a given straight line.



Let AB be the given straight line. At A erect the normal AK, and from it cut off AC $=$ AB. With centre C, radius AB, describe an arc, and with centre B and the same radius describe an arc, cutting the former in D. Join DC and DB.

CDBA is the square required.

Proof.—Join BC.

Because AC $=$ AB, $\angle ACB = \angle ABC$ (Euclid, I, 5).

But $\angle ACB + \angle ABC + \angle A = 180°$, and since $\angle A = 90°$

$\angle ACB + \angle ABC + 90° = 180°$

$\therefore \angle ACB + \angle ABC = 180° - 90° = 90°$

Hence each $= 45°$.

In $\triangle$s ABC and DBC

AB $=$ DB

AC $=$ CD

BC is common

$\therefore \triangle ABC = \triangle DBC$ (Euclid, I, 8.)

Hence $\angle D = \angle A = 90°$

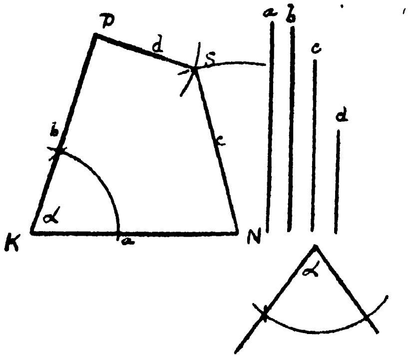
$\angle DCB = \angle ACB = 45°$

$\angle DBC = \angle ABC = 45°$

Hence whole $\angle ACD$ = whole $\angle ABD = 45° + 45° = 90°$.

Hence CDBA is a quadrilateral, having its 4 sides equal and its four angles right angles. It is therefore a square.

Construct a quadrilateral, given the sides and one angle.



Let a, b, c, d be the sides and a the angle between a and b.

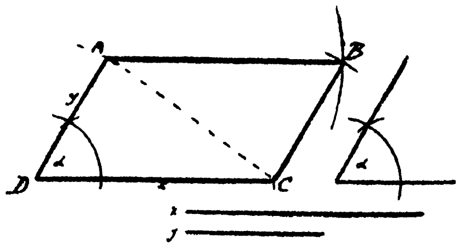
Draw a straight line KN $= a$, and at K make $\angle$NKP $= a$ and the arm KP $= b$.

With centre N and radius C describe an arc, and with centre P, radius d, describe an arc cutting the former in S. Join PS and NS.

PSNK is the required quadrilateral.

Observe that the arcs which intersect at S have a second point of intersection, S^1 (not shown). In this way a second quadrilateral may be formed, in which $\angle S^1$ is a reflex angle.

Construct a parallelogram, given two adjacent sides and included angle.



Let x and y be the given sides and a the included angle.

Draw a straight line $DC = x$, and at D make $\angle CDA = \angle a$ and arm $DA = y$. With centre C, radius y, draw an arc, and with centre A, radius x, draw an arc, cutting the former in B. Join AB and BC.

ABCD is the parallelogram required.

Proof.—Join AC.

In $\triangle$s ABC and ADC

$$AB = DC$$
$$BC = AD$$
$$AC \text{ is common}$$
$$\therefore \quad \triangle ABC = \triangle ADC \text{ (Euclid, I, 8).}$$

Hence $\angle BAC = \angle ACD$, and as these are alternate angles AB is parallel to DC. And since $AB = DC$, AD and BC, the straight lines joining the ends of two equal and parallel straight lines, AB and AC, are themselves equal and parallel.

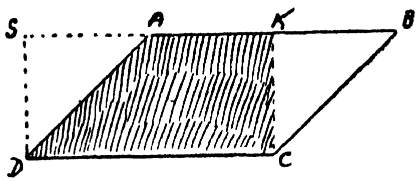
Hence ABCD is a parallelogram.

Areas

Under Arithmetic we have shown that the area of an oblong, or in geometrical language, a rectangle, is given by

$$\text{Length} \times \text{Breadth} = \text{Area.}$$

Find the area of a parallelogram.



Let ABCD be a parallelogram. At D erect a normal, and let BA produced meet this normal in S. Through C draw CK perpendicular to DC and let it meet AB in K.

Now SKCD is a rectangle, for the angle SDC $= 90°$. SD is parallel to KC and SK to DC.

Thus SKCD and ABCD are two parallelograms between the same parallels SB and DC.

The shaded quadrilateral AKCD is obviously common to both parallelograms.

In $\triangle$s SAD and KBC

$$\angle S = \angle BKC = 90°$$
$$\angle SAD = \text{interior opposite } \angle KBC$$
$$AD = BC$$
$$\therefore \quad \triangle SAD = \triangle KBC \text{ (Euclid, I, 26).}$$

Hence $\triangle SAD + AKCD = AKCD + \triangle KBC$

i.e. rectangle SKCD = parallelogram ABCD.

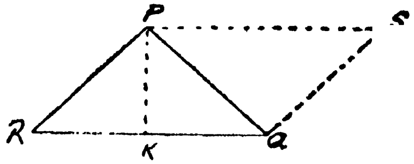
Now area of rectangle SKCD = base $\times$ height
= DC $\times$ DS

$\therefore$ Area of Parallelogram ABCD = DC $\times$ DS
= Base $\times$ perpendicular height.

Hence any parallelogram standing on DC and between the parallels SB and DC will be equal in area to the rectangle SKCD.

Consequently: *Parallelograms on the same base and between the same parallels are equal in area.* (Euclid, I, 35.)

Find the area of a triangle.

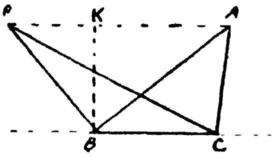


Let PQR be the given $\triangle$. Through Q draw QS $\parallel$ RP, and through P draw PS $\parallel$ RQ. Then PSQK is a parallelogram, and $\triangle PQR = \frac{1}{2}$PSQR.

Now area of parallelogram PSQR
= Base $\times$ perpendicular height (or *altitude*)
= RQ $\times$ PK where PK is the normal on RQ.

$\therefore$ Area of $\triangle PQR = \frac{1}{2}$ area of parallelogram PSQR
$= \frac{1}{2}$ (RQ $\times$ PK)
$= \frac{1}{2}$ (Base $\times$ altitude)
$= \frac{1}{2}$ the base multiplied by the height.

Triangles on the same base and between the same parallels are equal in area. (Euclid, I, 37. —A Theorem.)



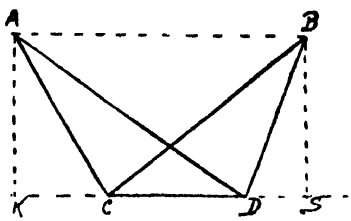
Let PBC and ABC be two triangles on same base BC and between the same parallel PA and BC.

It is required to prove $\triangle PBC = \triangle ABC$ in area.

From B draw BK, a normal, meeting PA in K. Then BK is the altitude of each triangle.

Proof.—Area of $\triangle PBC = \frac{1}{2}$ base $\times$ altitude.
$= \frac{1}{2}BC \times BK.$
Area of $\triangle ABC = \frac{1}{2}$ base $\times$ altitude
$= \frac{1}{2}BC \times BK.$
Hence $\triangle PBC = \triangle ABC.$

The Converse : If two triangles, equal in area, stand on the same base and on the same side of it they are between the same parallels. (Euclid, I. 39.)



Let $\triangle$s ADC and BCD stand on same base

CD and on the same side of it, and let $\triangle ADC = \triangle BCD$ in area.

It is required to prove that if their vertices A and B be joined, AB is parallel to CD.

Proof.—Produce the base CD both ways. Through A and B draw AK and BS perpendicular to CD produced and meeting it in K and S.

Now area of $\triangle ADC = \frac{1}{2}$ base $\times$ altitude
$= \frac{1}{2}CD \times AK$

so area of $\triangle BDC = \frac{1}{2}CD \times BS$

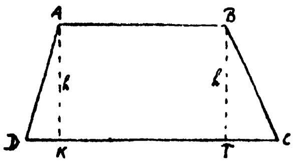
$\therefore$ since $\triangle ADC = \triangle BDC$

$\frac{1}{2}CD \times AK = \frac{1}{2}CD \times BS$

Divide each side by $\frac{1}{2}$CD and AK = BS.

And AK is parallel to BS since both are normals drawn to KS, hence AB is equal and parallel to KS.

Area of a Trapezium.—A *trapezium* is a quadrilateral with one pair of parallel sides.



Let ABCD be a trapezium having side AB $\parallel$ side DC. Through A and B draw AK and BT perpendicular to DC, and call AK or BT h, then ABTK is a rectangle whose area = base $\times$ height
$= KT \times AK$
$= KT \times h.$

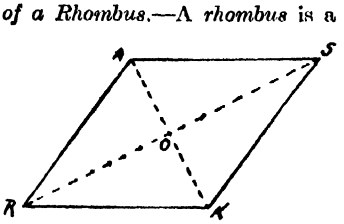
Area of $\triangle AKD = \frac{1}{2}$ base $\times$ height
$= \frac{1}{2}DK \times h.$

Area of $\triangle BCT = \frac{1}{2}TC \times h.$

Trapezium ABCD

$= \triangle AKD +$ rectangle $ABTK + \triangle BCT$
$= (\frac{1}{2}DK \times h) + (KT \times h) + (\frac{1}{2}TC \times h)$
$= h(\frac{1}{2}DK + KT + \frac{1}{2}TC)$
$= h[\frac{1}{2}DK + \frac{1}{2}(KT + AB) + \frac{1}{2}TC]$
$= \frac{1}{2}h(DK + KT + AB + TC)$
$= \frac{1}{2}h(DC + AB)$
$= \frac{1}{2}$ sum of parallel sides $\times$ altitude.

Area of a Rhombus.—A *rhombus* is a quadrilateral whose sides are equal but whose angles are not right angles.



Let ASKR be a rhombus, and let the diagonals AK and RS intersect at O.

The diagonals of a rhombus intersect at right angles.

Proof.—In $\triangle$s ASR and KSR the three sides of one $\triangle$ = three sides of the other.

$\therefore$ $\triangle ARS = \triangle KRS$ (Euclid, I, 8)

$\therefore$ $\angle ARS = \angle KRS.$

In $\triangle$s ARO and KRO

AR = RK

RO is common

included $\angle AKO$ = included $\angle KRO$

$\therefore$ $\triangle ARO = \triangle KRO$ (Euclid, I, 4)

$\therefore \angle AOR = \angle KOR$, hence each = 90°, and their vertically opposite $\angle$s SOK and SOA each = 90°.

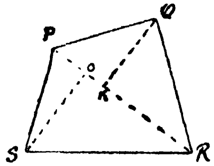
Again AO = OK, similarly RO = OS.

Area of rhombus ASKR

= area of $\triangle ARK$ + area of $\triangle ASK$
$= \frac{1}{2}AK.RO + \frac{1}{2}AK.SO$
$= \frac{1}{2}AK(RO + SO)$
$= \frac{1}{2}AK.RS.$

Hence *area of a rhombus is half the product of its diagonals.*

Area of any Quadrilateral.—Let PQRS be a quadrilateral. Draw a diagonal PR, and from S and Q drop normals SO and QK to PR.

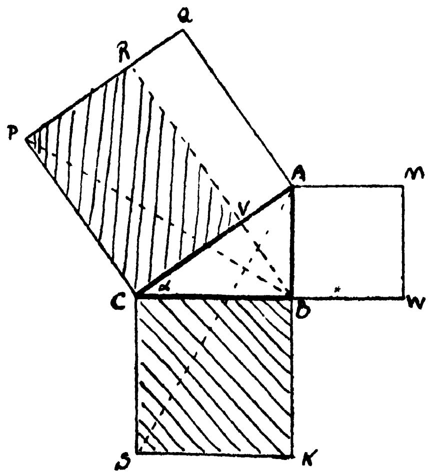


Then area of PQRS

= area of $\triangle PQR$ + area of $\triangle PRS$
$= (\frac{1}{2}PR \times KQ) + (\frac{1}{2}PR \times SO)$
$= \frac{1}{2}PR(KQ + SO).$

Note.—It is not necessary to memorise rules for areas. A figure should be drawn and divided into triangles, or sometimes (*e.g.* in case of the trapezium) into rectangles and triangles.

In a right-angled triangle the square described on the hypotenuse is equal to the sum of the squares described on the other two sides. (Euclid, I, 47.—A Theorem.)



Let ABC be a triangle right-angled at B.

It is required to prove that $CA^2 = AB^2 + BC^2$.

On CA describe the square CAQP
„ CB „ „ CBKS
„ AB „ „ AMWB

Join AS and BP, and through B draw BR parallel to CP.

$$\text{Area of } \triangle ACS = \tfrac{1}{2} \text{ base} \times \text{height}$$
$$= \tfrac{1}{2}CS \times CB$$
$$= \tfrac{1}{2}CB \times CB$$
$$= \tfrac{1}{2}CB^2$$

$\therefore$ $CB^2 =$ twice $\triangle ACS$

$$\text{Again, area of } \triangle PCB = \tfrac{1}{2} \text{ base} \times \text{height}$$
$$= \tfrac{1}{2}PC \times PR$$
$$= \tfrac{1}{2}(PC \times PR)$$
$$= \tfrac{1}{2} \text{ (rectangle PRVC)}$$

$\therefore$ rectangle PRVC = twice $\triangle PCB$.

In $\triangle$s ACS and PCB

AC = PC

CS = CB

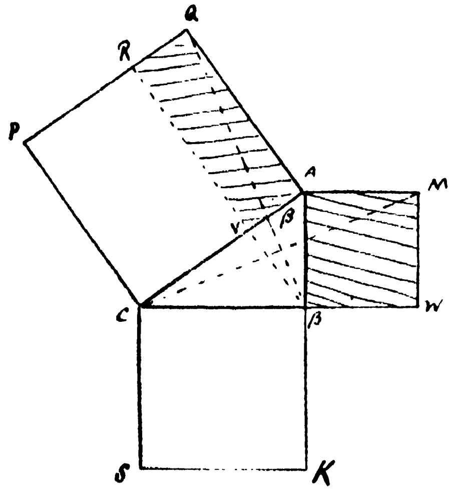
included $\angle ACS$ = included $\angle PCB$, because each $= 90° + \alpha$

$\therefore$ $\triangle ACS = \triangle PCB$.

But $\triangle ACS = \tfrac{1}{2}CB^2$, and $\triangle PCB = \tfrac{1}{2}$ rectangle PRVC,

$\therefore$ $\tfrac{1}{2}CB^2 = \tfrac{1}{2}$ rectangle PRVC

i.e. CB^2 = rectangle PRVC.



Join CM and QB (see 2nd figure).

$$\text{Then area of } \triangle ACM = \tfrac{1}{2} \text{ base} \times \text{height}$$
$$= \tfrac{1}{2}AM \times AB$$
$$= \tfrac{1}{2}AB \times AB = \tfrac{1}{2}AB^2$$

$$\text{Again, area of } \triangle QAB = \tfrac{1}{2} \text{ base} \times \text{height}$$
$$= \tfrac{1}{2}QA \times QR$$
$$= \tfrac{1}{2}\text{(rectangle RQAV)}.$$

In $\triangle$s ACM and QAB

AM = AB

AC = AQ

included $\angle CAM$ = included $\angle QAB$, because each $= 90° + \beta$

$\therefore$ ACM $\cong \triangle$ QAB (Euclid, I, 4).

But $\triangle ACM = \tfrac{1}{2}AB^2$, and $\triangle QAB = \tfrac{1}{2}$(rectangle RQAV),

$\therefore$ $\tfrac{1}{2}AB^2 = \tfrac{1}{2}$ rectangle RQAV

$\therefore$ AB^2 = rectangle RQAV.

Hence, since BC^2 = rectangle PRVC

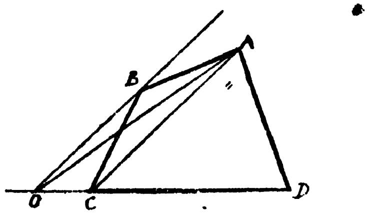
and AB^2 = rectangle RQAV

$BC^2 + AB^2$ = rect. PRVC + rect. RQAV

= PQAC

$= CA^2$.

Construct a triangle equal in area to the quadrilateral ABCD.



Join AC, and through B draw BO ∥ AC and meeting DC produced in O.

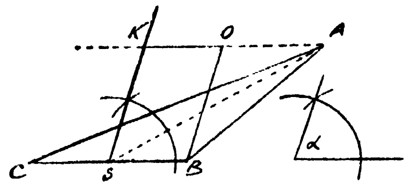
$\triangle ABC$ and $\triangle AOC$ are on same base AC and between parallels AC and BO, $\therefore$ $\triangle ABC = \triangle AOC$.

To each add $\triangle ADC$.

Then $\triangle ABC + \triangle ADC = \triangle AOC + \triangle ADC$

i.e. quadrilateral ABCD = $\triangle ADO$.

Construct a parallelogram equal in area to $\triangle ABC$ and having an angle equal to $\angle a$.



Bisect the base CB in S, and at S make $\angle BSK = \angle a$. Through A draw AK ∥ BC and meeting SK in K. Through B draw BO ∥ SK and meeting AK in O.

KOBS is the required parallelogram.

Proof.—$\triangle ABS = \triangle ASC$, because they are on equal bases CS and SB and between the same parallels KA and CB.

Parallelogram KOBS = twice $\triangle ABS$, because they stand on the same base SB and between the same parallels.

But $\triangle ABC = 2\triangle ABS$

$\therefore$ KOBS = $\triangle ABC$

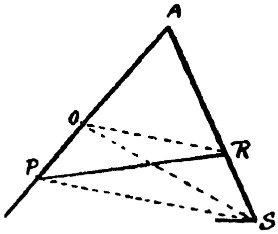
and $\angle KSB$ = given $\angle a$.

Bisect a triangle through a given point in one of its sides.

Let ASN be a triangle and P a point in the side AN.

It is required to draw from P a line bisecting $\triangle$ASN.

Find O, the mid-point of AN. Join OS, PS.



Through O draw OR parallel to PS and meeting AS in R. Join PR.

PR bisects $\triangle$ASN.

Proof.—$\triangle$s OPS and RPS stand on same base and between same parallels OR and PS, $\therefore$ $\triangle OPS = \triangle RPS$. To each add $\triangle$PSN.

Then $\triangle OPS + \triangle PSN = \triangle RPS + \triangle PSN$

i.e. $\triangle ONS =$ quadrilateral PRSN.

But $\triangle ONS = \triangle ASO$, because they stand on equal bases ON and OA and are of one altitude,

$\therefore$ $ONS = \frac{1}{2}\triangle ASN$

Hence quadrilateral $PRSN = \frac{1}{2}\triangle ASN$.

But quadrilateral $PRSN = \triangle ASN - \triangle ARP$

$\therefore$ $\frac{1}{2}\triangle ASN = \triangle ASN - \triangle ARP$

Thus $\triangle ARP = \triangle ASN - \frac{1}{2}\triangle ASN$
$= \frac{1}{2}\triangle ASN$
$=$ quadril. PRSN.

Hence PR divides $\triangle$ASN into two equal parts—$\triangle$ARP and quadrilateral PRSN.

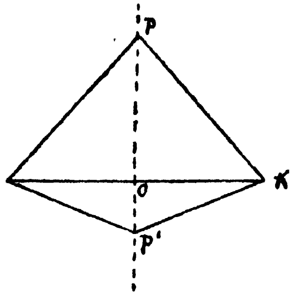
Loci

The Locus of a point is its path when it moves according to some definite law. For example, a point P moves round a centre O, keeping a definite distance from that centre. Obviously P traces a circle. Hence, when a point moves so that its distance from a given point is *constant*, the locus of the point is the circumference of a circle.

Again, suppose a point moves in a path such that its distance from a given straight line is constant. Think of the railway. If a mouse runs along the top of one rail its distance from the other rail is constant, *i.e.* it is always the same. Hence the locus of a point that moves so that its distance from a given straight line is constant is a straight line parallel to the given straight line.

Find the locus of a point P *which moves so that its distances from two fixed points* S *and* K *are equal.*

Join SK. Since P is to be always equidistant from S and K, its locus must pass through O, the mid-point of OK. Let P be one position of the moving point. Join PS and PK. PS



must be equal to PK. Hence PKS is an isosceles $\triangle$. Join OP.

In $\triangle$s PSO and PKO

PS = PK
PO is common
OS = OK

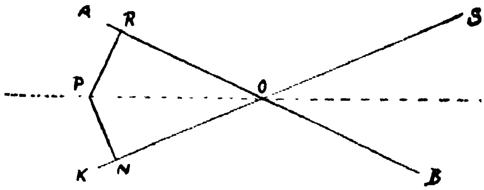
$\therefore$ $\triangle PSO \cong \triangle PKO$ (Euclid, I, 8)

$\therefore$ $\angle POS = \angle POK = 90°$.

It appears then that the locus of P is the straight line bisecting SK at right angles.

Take another position P^1 and apply the same proof.

Find the locus of a point P *that moves so that its distances from two given straight lines* AB *and* SK *are equal.*



Let AB and SK intersect at O. Let P be one of the point's positions. Then the distance of P from AB is PR, the normal on AB; so PN, the normal on KB, is P's distance from KS.

PR must be equal to PN.

Join PO.

In $\triangle$s PRO and PNO

$\angle PRO = \angle PNO = 90°$
$PR = PN$
PO is common

$\therefore$ $\triangle PRO \cong \triangle PNO$

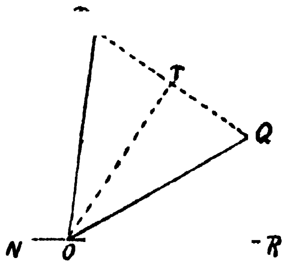
hence $\angle POR = \angle PON$

i.e. PO bisects $\angle$AOK, and consequently $\angle$SOB.

Hence *any point on the bisector of an angle is equidistant from the arms of the angle.*

PO might bisect the other two angles formed by the given lines.

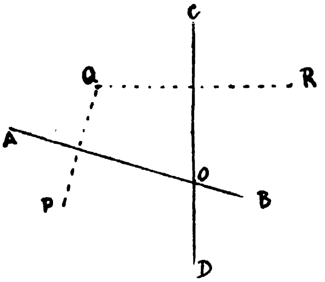
A point O *moves along a straight line* NR. *Find its position when it is equidistant from two points* P *and* Q.



Suppose O is one of the moving point's positions. Join OP and OQ. Then in the position required, OP = OQ. Join PQ. Then $\triangle$PQO is isosceles.

It can easily be shown that the straight line TO, bisecting PQ at right angles, fixes the position of the moving point when PO = QO.

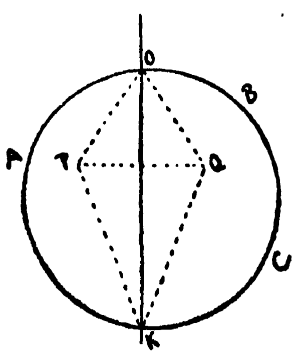
Find a point equidistant from three given points P, Q, R, *which are not in the same straight line.*



Join PQ, QR.

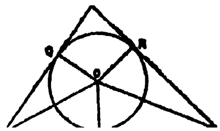
The locus of points equidistant from P and Q is AB, the perpendicular bisector of PQ. And the locus of points equidistant from Q and R is CD, the perpendicular bisector of QR. Hence the point O, where these bisectors intersect, is equidistant from P, Q, R. Prove by joining OP, OQ, OR.

Two points P *and* Q *within a circle* ABC *are fixed. Find points on the circumference equidistant from* P *and* Q.



Join PQ and draw perpendicular bisector OK. Prove that O and K are the points required.

Find a point within a triangle equidistant from the three sides.



Let ABC be the $\triangle$.

The locus of a point equidistant from AB and BC is the bisector of $\angle$ABC.

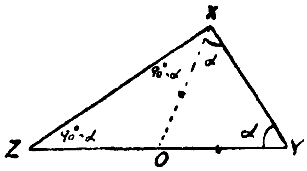
The locus of a point equidistant from AC and CB is the bisector of $\angle$ACB.

Let bisector BO meet bisector CO in O. O is equidistant from AB, BC, CA.

Prove by drawing normals OQ, OS, OR to AB, BC, CA, and comparing $\triangle$s OBQ and OBS, and $\triangle$s OSC and ORC.

Since OQ = OR = OS, a circle QRS can be drawn with centre O. Such a circle is called the Inscribed Circle of the $\triangle$ABC.

On a given base AB, *as hypotenuse, right-angled* $\triangle$*s*, ABC, ABC[1], ABC[2], *&c. are drawn. Find the locus of the vertices* C, C[1], C[2], *&c.*



Consider right-angled $\triangle$XYZ where $\angle X = 90°$.

At X make $\angle YXO = \angle Y$
$= a$

Then in $\triangle$OXY, $\angle YXO = \angle XYO$

$\therefore$ $\triangle$ is isosceles

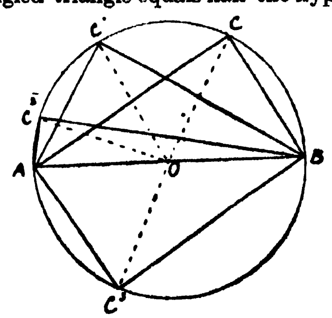
and OX = OY.

Then $\angle ZXO = \angle X - \angle OXY$
$= 90° - a$
$= \angle Z$

$\therefore$ OZ = OX (Euclid, I, 6).

Hence OX = OY = OZ.

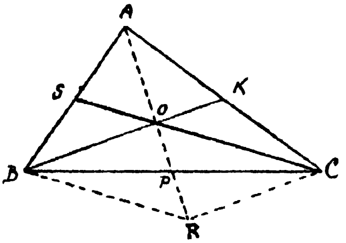
That is, the median drawn to the hypotenuse of a right-angled triangle equals half the hypotenuse.



On AB describe the right-angled $\triangle$s ABC and ABC[1]. Join O, the mid-point of AB, to C

and to C^1. Then OC is constant, because it is equal to $\frac{1}{2}$AB, *i.e.* half of a constant quantity. Similarly $OC^1 = \frac{1}{2}AB$, so also OC^2, OC^3. The vertices C, C^1, C^2, &c., are all the same distance from O, hence their locus is a circle with radius OC. (See Euclid, III, 31.)

The medians of a triangle are concurrent.



Let ABC be a $\triangle$, and BK and CS two of its medians intersecting at O. Join AO and produce it to meet BC in P. Then AP is the third median.

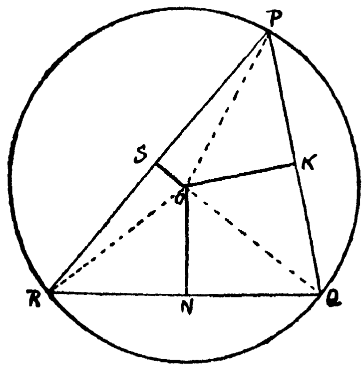
Proof.—Through C draw CR parallel to KB and let it meet AP produced in R. Join RB.

In $\triangle$ARC KO is drawn parallel to RC from K the mid-point of AC. $\therefore$ O is the mid-point of AR.

Again, since O is the mid-point of AR and S the mid-point of AB, OS is parallel to RB. Hence SOC is parallel to RB, and since BOK is parallel to RC, BOCR is a parallelogram. And the diagonals of a parallelogram bisect each other. $\therefore$ BP = PC, *i.e.* P is the mid-point of BC. Hence AP is a median, and the three medians meet at O.

Note.—O is called the *centroid* of the triangle ABC.

The normals drawn from the mid-points of the sides of a triangle are concurrent.



In $\triangle$PQR SO and KO are normals drawn from S and K, the mid-points of PR and PQ, and they meet in O. Find N, the mid-point of RQ, and join ON. ON is normal to RQ.

Proof.—Join OP, OR, OQ. Because OK bisects PQ at right angles, it is the locus of points equidistant from P and Q.

$\therefore$ OP = OQ.

Again SO is the locus of points equidistant from P and R.

$\therefore$ OP = OR

$\therefore$ OP = OR = OQ.

In $\triangle$s ORN and OQN

OR = OQ

ON is common

RN = NQ

$\therefore$ $\triangle ORN \cong \triangle OQN$ (Euclid, I. 8)

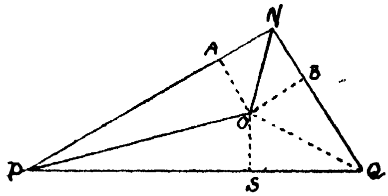
$\therefore$ $\angle ONR = \angle ONQ = 90°$.

that is, ON is normal to RQ.

Hence the normals from the mid-points of the sides meet in O.

Note.—Since OP = OR = OQ, a circle can be described round $\triangle$PRQ. This is known as the *circumcircle.*

The bisectors of the angles of a triangle are concurrent.



Let NQP be a triangle, and let PO and NO the bisectors of $\angle$P and $\angle$N meet at O. Join OQ. Then OQ bisects $\angle$Q.

Proof.—From O draw OA, OB, OS normals to NP, NQ, QP.

Because OP bisects $\angle$ P, OP is the locus of all points equidistant from PN and PQ.

$\therefore$ OA = OS.

Similarly NO is the locus of all points equidistant from NP and NQ.

$\therefore$ OA = OB.

Hence OA = OB = OS.

In $\triangle$s OBQ and OQS

OB = OS

$\angle OBQ = \angle OSQ = 90°$

OQ is common

$\therefore$ $\triangle OBQ \cong \triangle OQS$.

$\therefore$ $\angle OQB = \angle OQS$, *i.e.* OQ bisects $\angle$Q.

Hence OP, ON, OQ, the bisectors of angles P, N, Q, meet in a point.

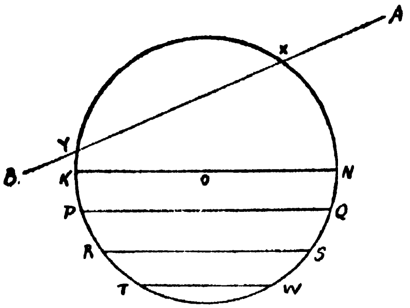
The Circle

We have defined terms like *circle, radius, arc,* &c. (p. 489), and under *Superposition* (p. 492) we showed that one circle was equal to another circle of the same radius.

Circles which have the same centre but unequal radii are said to be *Concentric.*

A Chord is any straight line joining two points on the circumference.

A Secant is a straight line which cuts the circumference at two points.



In the circle shown KN, PQ, RS, TW are chords, KN passing through the centre O. Thus the diameter of a circle is a chord. By inspection we conclude that the diameter is the greatest chord and the farther a chord is from the centre the smaller it is.

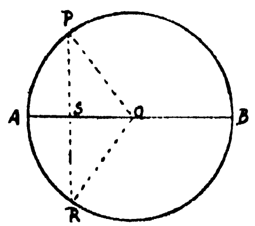
AB is a secant cutting the circle in X and Y. Obviously XY is a chord.

Symmetry.—A figure is said to be symmetrical about a line when, on being folded about that line the parts on each side exactly coincide with each other. In drawing, a symmetrical figure is called a balanced figure.

The straight line is called the *axis of symmetry.*

Show that the diameter is the axis of symmetry of a circle.

Method I. (*Practical*).—With a pair of scissors cut out a circle made on paper; cut along the diameter, and place one semicircle upon the other. They will be found to coincide exactly.



Method II. (*Theoretical*).—Take any point P on the circumference, and join OP. At O, on the opposite side of the diameter AB, make $\angle AOR = \angle AOP$.

Imagine the circle is folded about AB. Since $\angle AOP = \angle AOR$, OR will lie along OP, and since OR = OP, R will coincide with P. So every point on the arc ARB will coincide with some point on arc APB.

Hence circle ARB is symmetrical about AB. Join PR, and let PR cut AB in S.

In $\triangle$s SOP and SOR

OP = OR

OS is common

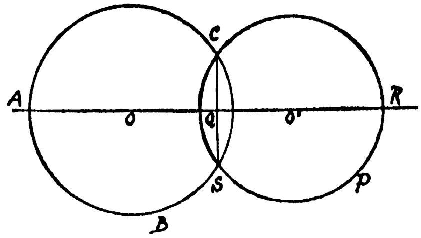
included $\angle SOP$ = included $\angle SOR$

$\therefore$ $\triangle SOP \cong \triangle SOR$ (Euclid, 1, 4)

$\therefore$ PS = SR

$\angle PSO = \angle RSO = 90°$.

Hence P and R are symmetrically opposite with regard to AB.



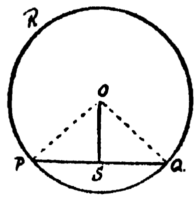
The straight line passing through the centres of two circles is called the *line of centres.*

Let two circles, ABC and CPR, intersect at C. Show that they must also intersect at a second point. Draw the line of centres OO^1. From C draw CQ normal to AR and produce it to S so that QC = QS.

Then C and S are symmetrically opposite points with regard to OO^1. And because C is on the circumference of both circles, S must also be on the circumference of both.

Note.—By construction CS, the common chord, is bisected at right angles by OO^1.

If a straight line drawn from the centre of a circle bisect a chord which does not pass through the centre, it cuts the chord at right angles. (Euclid, III, 3.)



Let PQR be a circle and O its centre. Let the straight line OS bisect the chord PQ.

It is required to prove that OS is a normal on PQ. Join OP, OQ. Then $\angle OSP = \angle OSQ = 90°$.

Proof.—In $\triangle$s OPS and OQS

OP = OQ

OS is common

PS = SQ

$\therefore$ OPS $\cong \triangle$ OQS (Euclid, I, 8)

$\therefore$ $\angle OSP = \angle OSA = 90°$, since they are adjacent angles.

Hence OS is a normal on PQ.

Converse.—*If a straight line drawn through the centre cuts a chord at right angles it bisects it.*

Let OS cut PQ at right angles.

It is required to prove PS = SQ.
Join OP and OQ.

Proof.—In $\triangle$s OPS and OSQ

$\angle OSP = \angle OSQ = 90°$

hypotenuse OP = hypotenuse OQ

side OS is common

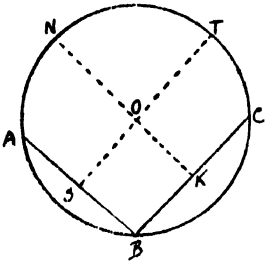
$\therefore \quad \triangle OPS \cong \triangle OSQ.$

Hence PS = SQ.

Corollary.—The straight line which bisects a chord at right angles passes through the centre of the circle.

From this we can deduce a method of finding the centre of a circle.

Find the centre of the circle ABC.



From B draw two chords BA and BC, and bisect them in S and K. Through S and K respectively draw ST and KN perpendicular to BA and BC, and let these normals meet in O.

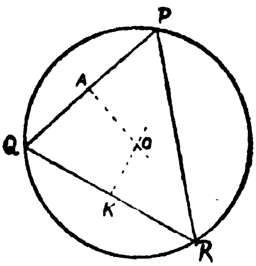
O is the centre of the circle.

Proof.—Since ST is normal to AB it passes through the centre, and since KN is normal to BC it passes through the centre (Euclid, III, 3). Hence the centre is O, a point common to ST and KN.

Only one circle can pass through three points not in the same straight line. (A Theorem.)

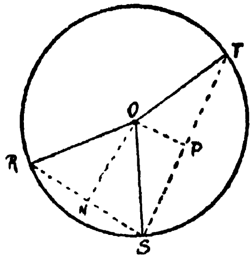
For in above figure O is the only point that is equidistant from A, B, and C which are not in the same straight line. Hence a circle with centre O and radius OA is the only one that can pass through B and C.

We can now find a method of describing a circum-circle about a triangle.



For the triangle PQR has three points P, Q, R not in the same straight line. A circle can be drawn through these points if QP and QR be considered as chords bisected by the normals AO and KO, which meet in O.

If from a point within a circle more than two equal straight lines can be drawn to the circumference, that point is the centre of the circle. (Euclid, III, 9.)



From the point O in the circle RST let three lines OR, OS, OT, drawn to the circumference, be equal. It is required to prove that O is the centre of the circle RST.

Join RS, ST; and join O to N and P, the mid-points of RS and ST.

Proof.—In $\triangle$s OPS and OPT

OS = OT

OP is common

SP = PT

$\therefore \quad \triangle OPS \cong \triangle OPT$ (Euclid, I, 8)

$\therefore \quad \angle OPS = \angle OPT = 90°$

Hence PO passes through the centre.

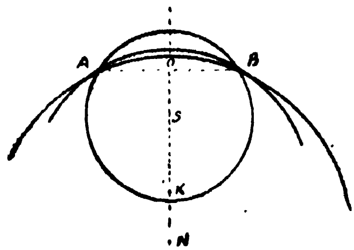
Similarly it may be shown that NO passes through the centre. Therefore O, the point of intersection, is the centre of the circle RST.

Describe a circle with radius r *to pass through two points* A *and* B.

Join AB. With centres A and B, radius r, describe two arcs intersecting in O. O is the centre of the circle. Join O to P, the mid-point of AB, and compare $\triangle$s OPA and OPB.

The problem is impossible if r is so short that the arcs do not intersect, or at least touch each other.

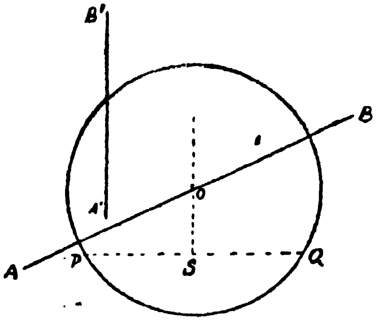
Find the locus of the centres of all circles passing through two given points A *and* B.



Join AB, and bisect AB by normal ON. Any point on ON is equidistant from A and B.

Hence ON is the locus of the centres of all circles passing through A and B. If NO be produced, circles having centres on the upper side of AB will pass through A and B.

Describe a circle which shall pass through two given points P *and* Q *and have its centre on a given straight line* AB.

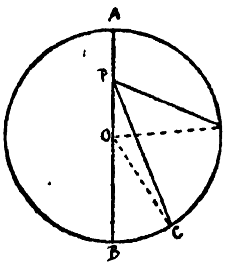


Join PQ, and bisect it by normal SO, meeting AB in O. O is equidistant from P and Q, hence a circle with radius OP will pass through Q.

When is the problem impossible? When AB is perpendicular to PQ.

Let AB take position A^1B^1. Obviously SO will never meet A^1B^1, since they are parallel straight lines.

If from a given point within a circle straight lines are drawn to the circumference, the greatest is that which passes through the centre, and the remaining part of that diameter is the least. (Euclid, III, 7.—A Theorem.)



Let P be the given point within circle ABC, and let APB be a diameter through P. Let PC and PD be other straight lines drawn from P to the circumference.

It is required to prove that
(1) PB is the greatest
(2) PA is the least
(3) PC is greater than PD.

Proof.—(1) Join OC and OD.

Then $\quad OB = OC$ and $PB = PO + OB$
$\qquad\qquad = PO + OC$

But in $\quad \triangle POC, PO + OC > PC$

$\therefore \quad PB > PC.$

Similarly PB may be shown to be greater than any other straight line from P to the circumference.

(2) In $\triangle OPD$, OD is less than $OP + PD$

But $OD = OA$

$\therefore \quad$ OA is less than $OP + PD$.

Take away the common part OP,

and $\quad OA - OP$ is less than $(OP + PD) - OP$

i.e. $\quad$ AP „ „ PD.

Similarly it may be shown that AP is less than any other straight line from P to the circumference.

(3) In $\triangle$s POC and POD

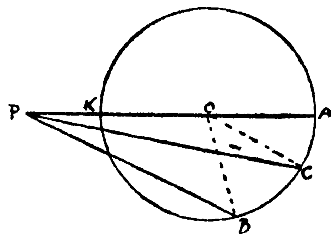
PO is common

$OC = OD$

$\angle POC > \angle POD$

$\therefore \quad$ PC is greater than PD (Euclid, I, 24).

If straight lines be drawn to the circumference of a circle from an external point, the greatest is that passing through the centre, and the least is that which when produced passes through the centre. Of two other such lines the greater is that subtending the greater angle at the centre. (Euclid, III, 8.—A Theorem.)



Let AKBC be the circle and P the given external point. Let PKA, PC, PB be lines drawn to the circumference, so that PKA passes through the centre O, and so that $\angle POC$ subtended by PC is greater than $\angle POB$ subtended by PB.

It is required to prove that
(1) PA is the greatest
(2) PK is the least
(3) PC is greater than PB.

Join OC and OB.

Proof.—(1) $\quad PA = PO + OA$
$\qquad = PO + OC$

but $\quad PO + OC > PC$

$\qquad PA > PC.$

Similarly it may be shown that PA is greater than any other straight line to the circumference from P.

(2) In $\triangle POB$, $PB + BO > PO$, *i.e.* $PK + KO$. But $KO = BO$. Subtract these, and $PB > PK$.

Similarly it may be shown that any other straight line from P to the circumference is greater than PK.

$\therefore \quad$ PK is the least of all such lines.

(3) In Δs POC and POB

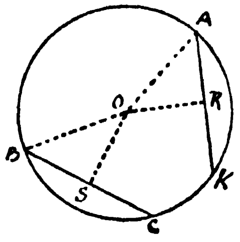
PO is common

$OC = OB$

included $\angle POC >$ included $\angle POB$

$\therefore$ base $PC >$ base PB (Euclid, I, 24).

Equal chords are equidistant from the centre. (Euclid, III, 14.—A Theorem.)



In the circle ABCK let chord BC = chord AK. Draw OS and OR normals from centre O to BC and AK.

It is required to prove $OS = OR$.

Join OA, OB.

Proof.—BC and AK are bisected by OS and OR (Euclid, III, 3).

In Δs SOB and ROA

$$\angle OSB = \angle ORA = 90°$$

$$\text{hypotenuse } OB = \text{hypotenuse } OA$$

$$BS = \tfrac{1}{2}BC = \tfrac{1}{2}AK = AR$$

$$\therefore \quad \Delta OSB \cong \Delta ORA$$

$$\therefore \quad OS = OR.$$

Converse.—Chords which are equidistant from the centre are equal.

Let BC and AK stand at equal distances OS and OR from centre O.

It is required to prove $BC = AK$.

Proof.—Join OB, OA.

OS being perpendicular to BC and passing through centre O bisects BC; similarly OR bisects AK.

In Δs OBS and ORA

$$OB = OA$$

$$OS = OR$$

$$\angle BSO = \angle ARO = 90°$$

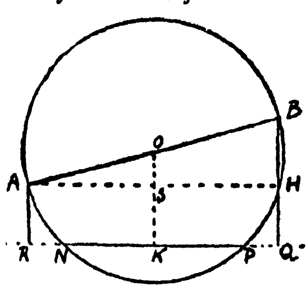
$$\therefore \quad \Delta OBS = \Delta ORA$$

$$\therefore \quad BS = AR$$

$$\textit{i.e.} \quad \tfrac{1}{2}BC = \tfrac{1}{2}AK$$

$$\therefore \quad BC = AK.$$

Note.—Since $OS = OR$, a circle with centre O radius OS will pass through R. Similarly it will pass through the mid-points of all chords equal to BC. Hence *the locus of the mid-points of equal chords is a circle having radius equal to the distance of each chord from the centre.*



Exercise.—If NP be a fixed chord of a circle ANPB, and AB any diameter, show that, if AR and BQ be normals from A and B on NP or NP produced, the sum or difference of AR and BQ is a constant.

Case I.—When R and Q are on NP produced. Let BQ meet the circumference in H.

Join AH. Then, as we have shown in discussing right-angled triangles, ΔAHB is a right-angled triangle, with the right-angle at H. Therefore $\angle$s H and Q are equal, and AH is parallel to RQ.

Join OK, K being the mid-point of NP, and let it cut AH in S.

Then OK is perpendicular to NP (Euclid, III, 3) and therefore AH.

Hence AR, OK, BQ being perpendicular to RQ, are parallel. Thus AHQR is a parallelogram, and $AR = SK = HQ$.

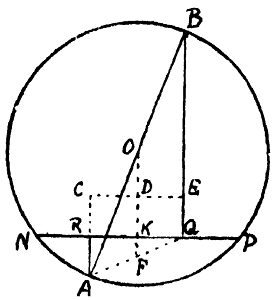
S is the mid-point of the chord AH, and the normal SO passes through O. And O is the mid-point of AB. Hence $OS = \tfrac{1}{2}BH$.

We have to show that $AR + BQ$ is constant.

$$\begin{aligned} AR + BQ &= AR + (BH + HQ) \\ &= SK + (2SO + SK) \\ &= (SK + SO) + (SO + SK) \\ &= OK + OK \\ &= 2OK, \text{ but OK is a constant since O is fixed and K is the mid-point of a fixed chord NP.} \end{aligned}$$

$\therefore$ 2OK is a constant.

Hence $AR + BQ =$ a constant.



Case II.—When normals AR and BQ fall wholly within the circle.

Produce AR to C, making $RA = RC$.

Through C draw CDE parallel to NP and cutting OK in D. Join AQ, and produce OK to meet AQ in F.

In ΔABQ OF bisects AB and is parallel to base BQ, $\therefore$ it bisects AQ. Hence $AF = FQ$, and $BQ = 2OF$.

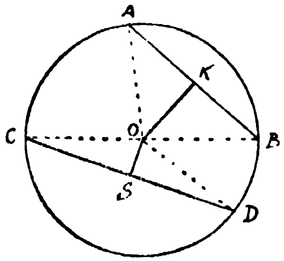
Similarly in ΔRAQ FK bisects RQ because FK is parallel to AR, and $RA = 2KF$.

$$\begin{aligned} \text{Hence } BQ - RA &= 2OF - 2KF \\ &= 2(OF - KF) \\ &= 2OK \end{aligned}$$

and since O is fixed and K is fixed, being mid-point of given chord NP, OK is fixed, *i.e.* OK is a constant.

$$\therefore \quad BQ - RA = 2OK = \text{a constant.}$$

Of two chords in a circle that which is nearer the centre is the greater. (Euclid, III, 15.)



In the circle ACDB let OK, the distance of the chord AB from the centre O, be greater than OS, the distance of the chord CD from the centre O.

It is required to prove that CD is greater than AB.

Join OA, OC.

Proof.—OS bisects CD, and OK bisects AB.

Because $\triangle$OAK is right angled at K
$OA^2 = AK^2 + KO^2$ (Euclid, I, 47).

Similarly because $\triangle$OCS is right angled at S

$$OC^2 = CS^2 + SO^2$$

But $OA = OC$

$\therefore$ $OA^2 = OC^2$

hence $AK^2 + KO^2 = CS^2 + SO^2$

But $KO > SO$

$\therefore$ $KO^2 > SO^2$

hence $KO^2 = SO^2 +$ some quantity.

Substitute this value for KO^2 in above equation, and $AK^2 + SO^2$ + some quantity $= CS^2 + SO^2$.

Subtract SO^2 from each side, and AK^2 + some quantity $= CS^2$.

Hence $CS^2 > AK^2$

$\therefore$ $CS > AK$

i.e. $\frac{1}{2}CD > \frac{1}{2}AB$

$\therefore$ $CD > AB$.

Converse.—The greater of two chords is nearer to the centre than the less.

Let CD be greater than AB.

OS and OK are the normals from centre O to CD and AB.

It is required to prove OK greater than OS.

Join OB and OD.

Proof.—As before $SD = \frac{1}{2}CD$ and $KB = \frac{1}{2}AB$.

In $\triangle$OKB, $OB^2 = OK^2 + BK^2$, and in $\triangle$OSD, $OD^2 = OS^2 + SD^2$. But $OB^2 = OD^2$, because $OB = OD$.

$\therefore$ $OK^2 + KB^2 = OS^2 + SD^2$

But $SD > KB$

$SD^2 > KB^2$.

Hence $SD^2 = KB^2$ + some quantity.

Substitute this value for SD^2 in equation and $OK^2 + KB^2 = OS^2 + KB^2 +$ some quantity.

Subtract KB^2 from each side

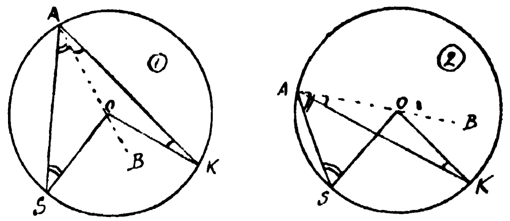
and $OK^2 = OS^2 +$ some quantity

i.e. $OK^2 > OS^2$

$\therefore$ $OK > OS$.

Corollary.—A diameter is the greatest chord in a circle.

The angle at the centre of a circle is double of an angle at the circumference standing on the same arc. (Euclid, III, 20.)



Let SK be the arc, and let SAK be the angle at the circumference and SOK the angle at the centre, both standing on the arc SK.

It is required to prove that $\angle SOK =$ twice $\angle SAK$.

Join AO and produce it to B.

Proof.—(1) In $\triangle$AOK exterior $\angle BOK =$ interior $\angle OAK +$ interior $\angle OKA$.

But $\angle OAK = \angle OKA$, since $OA = OK$.

$\therefore$ $\angle BOK =$ twice $\angle OAK$.

Similarly $\angle BOS =$ twice $\angle SAO$ of $\triangle$SAO

Add, and $\angle BOK + \angle BOS = 2\angle OAK + 2\angle SAO$

i.e. $\angle SOK = 2(\angle OAK + \angle SAO)$
$= 2\angle SAK$.

(2) In Fig. 2 $\angle BOK = 2\angle OAK$

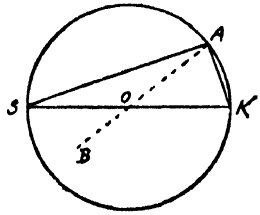
and $\angle BOS = 2\angle SAO$.

Subtract,

and $\angle BOS - \angle BOK = 2\angle SAO - 2\angle OAK$

i.e. $\angle SOK = 2(\angle SAO - \angle OAK)$
$= 2\angle SAK$.

The angle in a semicircle is a right angle. (Euclid, III, 31.)



For let the arc SK be a semicircle.

Then $\angle SOB = 2\angle SAO$

and $\angle BOK = 2\angle OAK$

$\therefore$ $\angle SOB + \angle BOK + 2\angle SAO + 2\angle OAK$

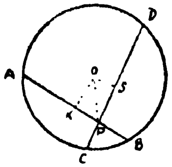
i.e. the straight angle $SOK = 2(\angle SAO + \angle OAK)$
$= 2\angle SAK$.

But $\angle SOK = 180°$

$\therefore$ $2\angle SAK = 180°$

$\therefore$ $\angle SAK = 90°$.

Find the locus of the mid-points of chords of a circle drawn through a fixed point.

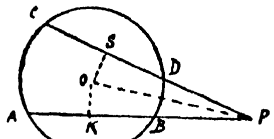


Case I.—When the point is *within* the circle.

Let P be a fixed point within circle ACBD, and let the chords AB and CD pass through P. Let K and S be the mid-points of AB and CD. Join centre O to K, P, S.

Then $\angle OKP = 90°$ and $\angle OSP = 90°$. Hence each is the angle in a semicircle.

Bisect OP, and with radius $\frac{1}{2}$OP describe a circle. This circle passes through K and S and all other mid-points of chords drawn through P. Hence the locus of such mid-points is a circle with OP as diameter.

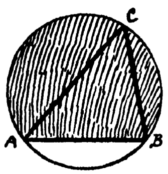


Case II.—When the point P is *outside* the circle.

Join centre O to K and S, the mid-points of chords AB and CD. Join OP.

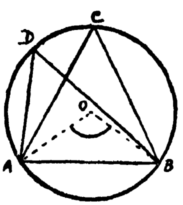
Then $\angle OSP$ and $\angle OKP$ are right angles.

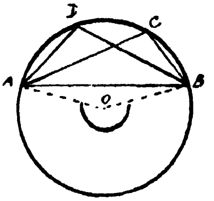
Hence locus of points S and K is a circle with OP as diameter.



Definition.—A **Segment** of a circle is a part bounded by a chord and one of the arcs into which the chord divides the circumference. The chord AB divides the circle ABC into two segments (the larger one is shaded). The angle ACB standing on the dividing chord is called an **angle in a segment.**

Angles in the same segment of a circle are equal. (Euclid, III, 21.—A Theorem.)





Let the $\angle$s ADB and ACB be in the same segment of the circle ABC.

It is required to prove $\angle ADB$ equal to $\angle ACB$.

Join centre O to A and B.

Proof.—

(Fig. 1). $\angle AOB = 2\angle ADB$ (Euclid, III, 20)

and $\angle AOB = 2\angle ACB$ „ „

$\therefore$ $2\angle ADB = 2\angle ACB$

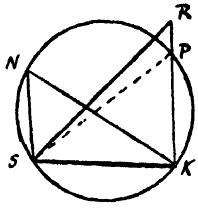
$\therefore$ $\angle ADB = \angle ACB$.

(Fig. 2). Reflex $\angle AOB = 2\angle ADB$

$= 2\angle ACB$

$\therefore$ $\angle ADB = \angle ACB$.

Converse.—*Equal angles standing on the same side of the same base have their vertices on an arc of a circle of which the given base is a chord.*



Let angles SNK and SRK be equal, and let them stand on the same base SK and on the same side of it.

It is required to prove that N and R lie on an arc of a circle of which SK is a chord.

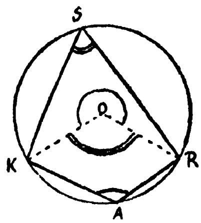
Proof.—N, S, K are three points not in a straight line, therefore a circle which passes through these points may be described.

Let the $\odot$ NSK cut KR in P. Join PS.

Then $\angle N = \angle SPK$, because in same segment. But $\angle N = \angle R$ by hypothesis, $\therefore$ $\angle SPK = \angle R$, *i.e.* an exterior angle of $\triangle SPR$ = interior opposite angle, which is impossible.

Hence the $\odot$ NSK will pass through R only when R coincides with P.

The opposite angles of a quadrilateral inscribed in a circle are together equal to two right angles. (Euclid, III. 22.—A Theorem.)



Let SKAR be a quadrilateral inscribed in $\odot$ SKAR.

It is required to prove that $\angle S + \angle A = 180°$.

Proof.—Join centre O to K and R.

Then $\angle KOR = 2\angle S$ (Euclid, III, 20)

and reflex $\angle KOR = 2\angle A$ „ „

$\therefore \angle KOR + \text{reflex} \angle KOR = 2\angle S + 2\angle A$

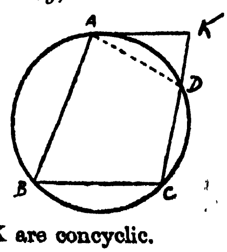
But $\angle KOR + \text{reflex} \angle KOR = 360°$

$\therefore$ $2\angle S + 2\angle A = 360°$

Cancel by 2, and $\angle S + \angle A = 180°$

Similarly $\angle K + \angle R = 180°$.

Converse.—*If a pair of opposite angles of a quadrilateral are supplementary, the vertices are concyclic.*



Note.—Points are concyclic when they lie on the circumference of a circle.

Let ABCK be a quadrilateral having $\angle B$ and $\angle K$ supplementary.

It is required to prove that the points A, B, C, K are concyclic.

Proof.—A circle can be described through the three points A, B, C. Let the ⊙ ABC cut CK in D. Join AD.

Since ABCD are concyclic,

$$\angle B + \angle ADC = 180°.$$

But by hypothesis $\angle B + \angle K = 180°$,

$\therefore \quad \angle B + \angle ADC = \angle B + \angle K$

i.e. $\quad \angle ADC = \angle K$, which is impossible, since $\angle ADC$ is the exterior angle of $\angle ADK$, and is thus greater than $\angle K$, the interior opposite angle.

Hence a circle passing through A, B, C must pass through K.

$\therefore$ K must coincide with D.

Exercise.—*In above figure prove* $\angle ADK = \angle B$.

$\angle B + \angle ADC = 180°$

and $\angle ADC + \angle ADK = 180°$

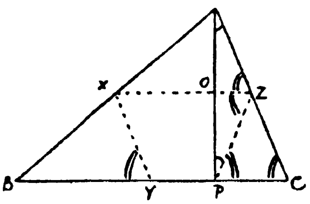
$\therefore \quad \angle B + \angle ADC = \angle ADC + \angle ADK$.

Take away common $\angle ADC$, and

$$\angle B = \angle ADK.$$

Hence if a side of a cyclic quadrilateral is produced, the exterior angle is equal to the opposite interior angle of the quadrilateral.

ABC *is a triangle, and* X, Y, Z *the mid-points of its sides.* AP *is the normal from the vertex* A *to the base* BC. *Show that the points* X, Y, P, Z *are concyclic.*



Join XZ, XY, PZ.

Then XZ, the straight line joining the mid-points of two sides AB and AC of $\triangle ABC$, is parallel to the third side BC. Similarly XY is parallel to AC. In $\triangle APC$, ZO, drawn from mid-point of AC parallel to base, bisects AP.

In right-angled $\triangle APC$, Z, the mid-point of the hypotenuse, is equidistant from A, P, C, *i.e.* $AZ = ZP = ZC$.

Since $ZP = ZC$, $\angle ZPC = \angle ZCP$.

But $\angle ZCP = \angle XYB = \angle AZX$ (Euclid, I, 29)

$\therefore \quad \angle ZPC = \angle AZX$

But $\angle ZPC = \angle XZP$ (Euclid, I, 29)

hence $\quad \angle XZP = \angle AZX$

$\therefore \quad \angle XZP = \angle XYB$.

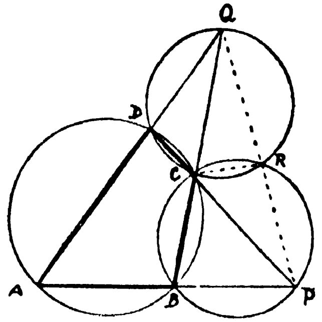
To each add $\angle XYP$,

then $\quad \angle XZP + \angle XYP = \angle XYB + \angle XYP$
$= 180°$

that is, $\angle XZP$ and $\angle XYP$, the opposite angles of quadrilateral XZPY, are supplementary, hence a circle may be described through the points XZPY (Euclid, III, 22, converse).

ABCD *is a cyclic quadrilateral, and the opposite sides* AB *and* DC *are produced to meet in* P, *and* AD *and* BC *to meet in* Q. *Show that if the circles circumscribed about triangles* CBP *and* QDC *meet in* R, *then* Q, R, *and* P *are collinear* (i.e. *lie in a straight line*).

Join RQ, RP, RC.



Proof.—Quadrilateral CRPB inscribed in a circle has exterior $\angle ABC$ = interior opposite $\angle CRP$. Similarly quadrilateral DCRQ inscribed in a circle has exterior $\angle ADC$ = interior opposite $\angle QRC$.

$\therefore \quad \angle ABC + \angle ADC = \angle CRP + \angle QRC$.

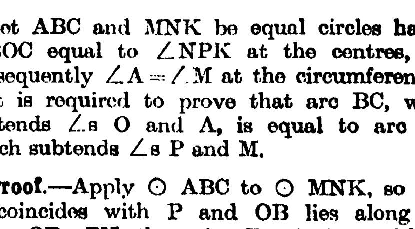
But $\quad \angle ABC + \angle ADC = 180°$

$\therefore \quad \angle CRP + \angle QRC = 180°$

$\therefore$ QR and RP are in the same straight line, *i.e.* Q, R, P are collinear.

Equal Circles

In equal circles arcs which subtend equal angles either at the centre or the circumference are equal. (Euclid, III, 26.—A Theorem.)



Let ABC and MNK be equal circles having $\angle BOC$ equal to $\angle NPK$ at the centres, and consequently $\angle A = \angle M$ at the circumference.

It is required to prove that arc BC, which subtends $\angle$s O and A, is equal to arc NK, which subtends $\angle$s P and M.

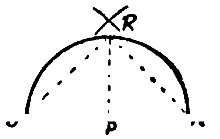
Proof.—Apply ⊙ ABC to ⊙ MNK, so that O coincides with P and OB lies along PN. Since $OB = PN$, the point B coincides with the point N.

Again, because $\angle O = \angle P$, OC lies along PK; and since $OC = PK$, the point C coincides with the point K.

Hence the arc BC coincides with the arc NK, *i.e.* arc BC = arc NK.

Note.—If the equal angles are in the same circle, the arcs subtending them are equal.

To bisect a given arc.



Let SRK be the arc.

Join SK, and at P, the mid-point of SK, erect the normal PR, cutting the arc in R. Join SR, KR.

RP is the locus of points equidistant from S and K.

∴ RS = RK

and ∠RSK = ∠RKS.

Now in a circle equal angles stand on equal arcs.

Hence since ∠RSK stands on arc RK

and ∠RKS stands on arc RS,

arc RK = arc RS.

that is, arc SRK is bisected in R.

Definition.—A **sector** of a circle is a figure bounded by an arc and two radii.

In equal circles angles, either at the centre or at the circumference, which stand on equal arcs are equal. (Euclid, III, 27.—A Theorem.)

Use figure in Euclid III, 26.

Let ABC and MNK be equal circles, and let arc BC = arc NK.

It is required to prove

(1) ∠O = ∠P

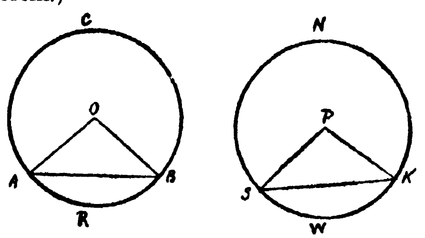
(2) ∠A = ∠M.

Proof.—Apply ⊙ ABC to ⊙ MNK so that O falls on P and OB along PN. Since OB = PN, point B falls on point N, and circumference of ⊙ ABC coincides with that of ⊙ MNK.

Since arc BC = arc NK, point C coincides with point K. Hence OC coincides with PK, *i.e.* ∠O = ∠P

and $\angle A = \frac{1}{2}\angle O = \frac{1}{2}\angle P = \angle M$.

In equal circles arcs cut off by equal chords are equal, the major arc equal to the major arc, the minor to the minor. (Euclid, III, 28.—A Theorem.)



Let circles ABC and SKN be equal, and let chord AB = chord SK.

It is required to prove that

(1) Major arc ACB = major arc SNK.

(2) Minor arc ARB = minor arc SWK.

Join AO, BO, SP, KP.

Proof.—In △s AOB and SPK the three sides of one equal the three sides of the other.

∴ △AOB ≅ △SPK

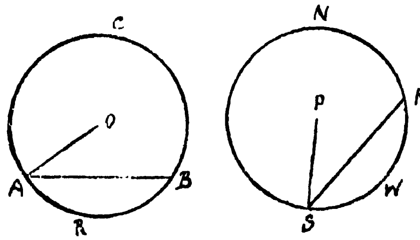
hence ∠O = ∠P

∴ arc ARB = arc SWK (Euclid, III, 26).

But whole circumference ABC = whole circumference SKN

∴ remaining arc ACB = remaining arc SNK.

In equal circles chords which cut off equal arcs are equal (Euclid, III, 29.—A Theorem.)



Let ⊙s ABC and SKN be equal, and let chords AB and SK cut off equal arcs ARB and SWK.

It is required to prove that chord AB = chord SK.

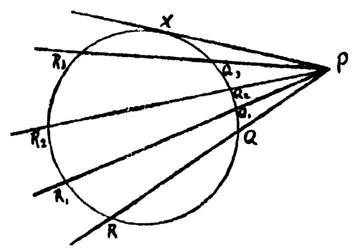
Join OA, PS.

Proof.—Apply ⊙ ABC to ⊙ SKN so that centre O falls on centre P and OA along PS. Since OA = PS, point A coincides with point S, and circumference ABC coincides with circumference SKN.

Since arc ARB = arc SWK, point B coincides with point K.

Hence AB coincides with SK

i.e. AB = SK.

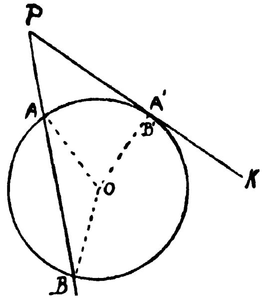


The Tangent.—Let PQR be a secant of the circle XQR, and let it be rotated about P, so that it takes the positions PQR, PQ_1R_1, PQ_2R_2, PQ_3R_3. After it passes through the centre, the points Q and R approach each other more and more, until when the secant touches the circumference, Q and R coincide at X.

PX *is a tangent to the circle.*

Definition.—A *tangent* (Latin, *tango*, I touch) to a circle is a straight line which touches the circumference at one point, but does not cut the circumference.

A tangent is perpendicular to the radius drawn to the point of contact.



Let PAB be a secant of ⊙ ABA^1, whose centre is O, and let it cut circumference in A and B. Join OA, OB.

$$\text{Then in } \triangle OAB$$
$$OA = OB$$
$$\therefore \quad OAB = \angle OBA \text{ (Euclid, I, 5)}$$

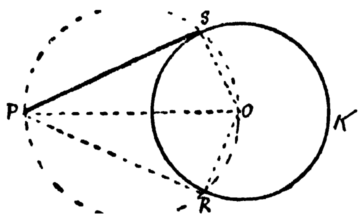
hence $\angle OAP$ the supplement of $\angle OAB = \angle OBK$ the supplement of $\angle OBA$.

Rotate secant PABK until it becomes the tangent PK^1. A and B now coincide at the point of contact, and OA coincides with OB. Hence the equal $\angle$s OAP and OBK become adjacent.

$\therefore$ OA^1 (or OB^1) is a normal on PK^1.

The above method of proof is called the *Method of Limits.*

To draw a tangent to a circle from a given point.



Let P be the given point and SKR the ⊙ having centre O.

Join PO, and on PO describe the semicircle PSO cutting circumference of ⊙ SKR in S. Join PS.

PS is the tangent required.

Proof.—$\angle PSO$ being the angle in a semicircle is a right angle, hence PS is perpendicular tc the radius OS.

$\therefore$ PS is a tangent to ⊙ SKR.

Another tangent PR can be drawn in the same way.

It can be shown that PS = PR.

For in right-angled $\triangle$s POS and POR

hypotenuse OP is common

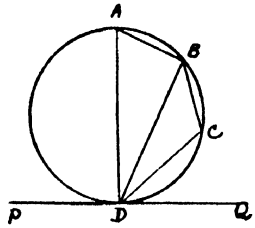
side OS = side OR

$\therefore$ $\triangle POS \cong \triangle POR$

hence PS = PR

$\angle POS = \angle POR$, &c.

The angles made by a tangent of a circle with a chord drawn from the point of contact are respectively equal to the angles in the alternate segments of the circle. (Euclid, III, 32.—A Theorem.)



Let PQ be a tangent to ⊙ ABCD touching it at D. Let DB be a chord.

Then I $\angle BDQ$ = angle in alternate segment BAD

II $\angle BDP$ = angle in alternate segment BCD.

Through D draw diameter DA. Take any point C in arc BCD. Join AB, BC, CD.

Proof.—$\angle ABD = 90°$ because angle in a semicircle $= \angle ADQ$

Again $\angle ABD = \angle A + \angle ADB$

and $\angle ADQ = \angle ADB + \angle BDQ$

$\therefore$ $\angle A + \angle ADB = \angle ADB + \angle BDQ$

take away common $\angle ADB$ and $\angle A = \angle BDQ$.

Again ABCD is a quadrilateral in a circle

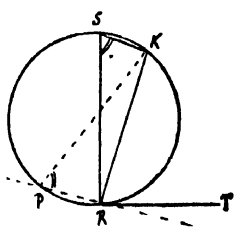
$\therefore$ $\angle A + \angle C = 180°$

i.e. $\angle BDQ + \angle C = 180°$

But $\angle BDQ + \angle BDP = 180°$.

$\therefore$ $\angle BDQ + \angle C = \angle BDQ + \angle BDP$.

Take away common $\angle BDQ$, and $\angle C = \angle BDP$.



Proof by Method of Limits.—Let ⊙ SKR have a chord RK, and let PRT^1 be any secant through R. Draw diameter RS. Join SK, KP.

Then $\angle S = \angle P$ (Euclid, III, 21).

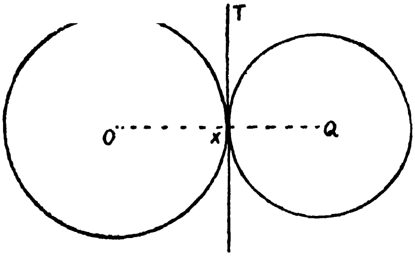
Rotate secant PRT^1 about R until P coincide with R and secant PRT^1 becomes tangent RT.

$$PR=0$$

$\therefore$ KP coincides with KR

Hence $\angle KPR$ has become $\angle KRT$

$\therefore$ $\angle KRT=\angle S$.

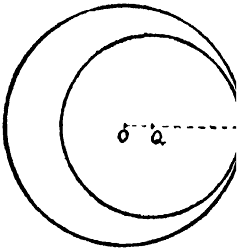


Common Tangent.—Let T be a common tangent to circles that touch at point X.

$$\angle TXO=90°$$

and $\angle TXQ=90°$.

$\therefore$ O, X, Q are in the same straight line.

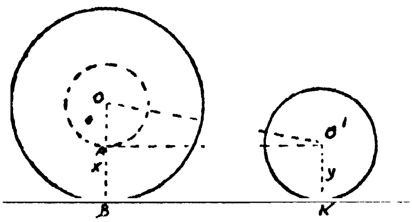


When the circles touch internally (Fig. 2)

$$\angle TXO=\angle TXQ.$$

$\therefore$ O, Q, X are in the same straight line.

To draw a common tangent to two circles that do not touch each other.



Case I.—Let the circles have centres O and O^1. Let the radius $OB=x$ and $O^1K=y$. Suppose BK is the tangent. Join OB, O^1K. Then OB and O^1K are normals on BK. Join O and O^1.

Through O^1 draw O^1A parallel to KB and meeting x in A. Then $O^1K=AB$, because opposite sides of a parallelogram.

With centre O, radius OA, describe a circle.

O^1A is a tangent to this circle.

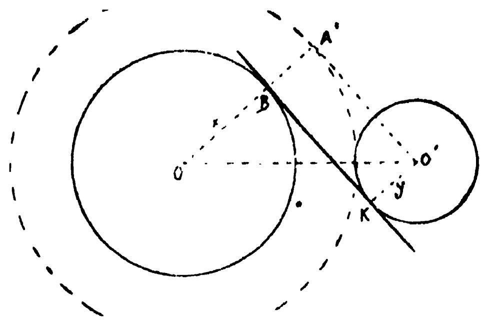
And the radius of this circle is OA.

But
$$OA=OB-AB$$
$$=OB-O^1K$$
$$=x-y.$$

Construction.—With centre O, radius $x-y$ describe a circle. From O^1 draw O^1A, a tangent to this circle. Join OA, and produce it to meet circumference of big circle in B. Through O^1 draw O^1K parallel to OB, and let it meet circumference of small circle in K. Join BK.

BK is the required common tangent, and is called the direct common tangent.

Case II.—When the tangent comes between the circles.



Suppose BK to be the tangent. Through O^1 draw OA^1 parallel to KB, and let it meet OB produced in A^1.

Then
$$O^1K=A^1B$$
$$OA^1=OB+BA^1$$
$$=OB+O^1K$$
$$=x+y.$$

Construction.—Join O, O^1. With centre O, radius $x+y$, describe a circle, and from O^1 draw O^1A, a tangent to this circle.

Join OA^1, and let it cut big circle in B. Through O^1 draw O^1K parallel to A^1B, and let it cut little circle at K. Join BK.

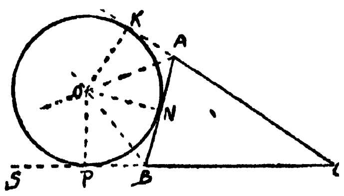
BK is the required common tangent, and is called the transverse common tangent.

General Problems on the Circle.—*Circumscribe a circle about a given triangle.* (See p. 510.)

Inscribe a circle in a given triangle. (See p. 509.)

Draw an escribed circle of a given triangle.

Note.—The escribed circle of a triangle touches one side and the other two sides produced.



Let the sides CA and CB of the given $\triangle ABC$ be produced to R and S.

The escribed circle will touch RA, AB, BS.

Suppose it touches RA at K, AB at N, BS at P. Join O, the centre, to K, N, P. Then OK $=$ ON $=$ OP, *i.e.* O is equidistant from the straight lines RA, AB, BS.

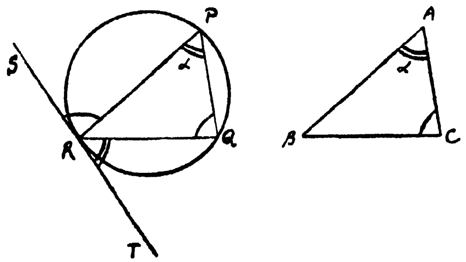
The locus of points equidistant from RA and AB is the bisector of $\angle$RAB, and the locus of points equidistant from AB and BS is the bisector of $\angle$ABS.

Hence the first step in the problem is to bisect $\angle$s RAB, ABS. The point O, where the bisectors intersect, is the centre of the escribed $\odot$ KNP.

Note.—O, being equidistant from RC and SC, stands on the bisector of $\angle$RCS. Hence, if OC be joined, OC bisects $\angle$C.

It follows that *the bisectors of two exterior angles of a triangle and the bisector of the third angle are concurrent, the point of intersection being the centre of the escribed circle.*

In a given circle inscribe a triangle equiangular to a given triangle.



Let ABC be the given triangle and PQR the given circle.

Draw any tangent SRT touching $\odot$PQR at R. At R make $\angle$TRQ $=$ $\angle$A (call it a). At R make $\angle$SRP $=$ $\angle$C. Join PQ.

PRQ is the required triangle.

Proof.—

$\angle$TRQ $=$ $\angle$P in alternate segment

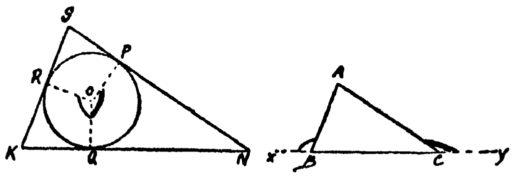
$=$ $\angle$A (Euclid, III, 32)

$\angle$SRP $=$ $\angle$Q in alternate segment

$=$ $\angle$C (Euclid, III, 32)

$\therefore$ $\angle$PRQ $=$ $\angle$B.

About a given circle circumscribe a triangle equiangular to a given triangle.



Let ABC be the given triangle and PQR the given circle, having centre O.

Produce BC both ways to x and y.

Draw any radius OQ, and at O make $\angle$QOR $=$ $\angle$ABX and $\angle$QOP $=$ $\angle$ACY, and let OR and OP be radii.

Through R, P, Q draw the tangents SK, SN, NK.

SKN is the required triangle.

Proof.—ROQK is a quadrilateral having opposite $\angle$s R and Q each a right angle, $\therefore$ remaining $\angle$s ROQ and K are together equal to 180°.

But $\angle$ABX $+$ $\angle$ABC $=$ 180°

$\therefore$ $\angle$ROQ $+$ $\angle$K $=$ $\angle$ABX $+$ $\angle$ABC

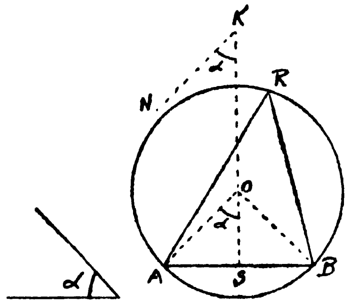
But $\angle$ROQ $=$ $\angle$ABX

$\therefore$ remaining $\angle$K $=$ remaining $\angle$ABC.

Similarly $\angle$N, the supplement of $\angle$QOP $=$ $\angle$C, the supplement of $\angle$ACY.

Hence third $\angle$S $=$ third $\angle$A.

On a given straight line describe a segment of a circle which will contain an angle equal to a given angle.



Let AB be the given straight line, and a the given angle.

Bisect AB at S, and erect the normal KS. At K make $\angle$SKN $=$ a.

Through A draw AO parallel to NK, and let it meet KS in O. Join OB.

KS is the locus of points equidistant from A and B, $\therefore$ OA $=$ OB.

With centre O, radius OA, describe a circle through A and B.

$\triangle$AOS $\cong$ $\triangle$BOS (Euclid, I, 8)

$\therefore$ $\angle$AOS $=$ $\angle$BOS

But $\angle$AOS $=$ $\angle$NKS $=$ a

$\therefore$ $\angle$AOS $=$ $\angle$BOS $=$ a

Hence whole $\angle$AOB $=$ $2a$.

Take any point R in the large segment made by the chord AB. Join RA, RB.

$\angle$AOB at centre $=$ 2$\angle$ARB at circumference

i.e. $2a = 2\angle$ARB

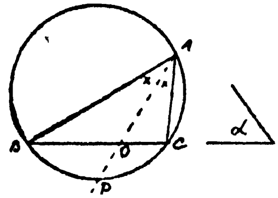
or $a = \angle$ARB.

Hence on AB a segment of a circle ARB has been described containing an angle equal to given $\angle a$.

Construct a triangle, given the base, vertical angle, and point where bisector of vertical angle cuts base.

Make a rough $\triangle$ABC and circumscribe it with a circle.

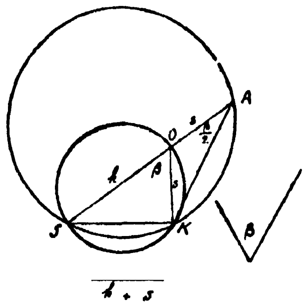
Suppose O is point where bisector of vertical $\angle A$ meets base BC. Then $\angle OAB = \angle OAC$. Hence these angles stand on equal arcs. Produce AO to meet circumference in P. Then arc BP = arc PC.



Construction.— On BC describe segment of a circle containing $\angle A$, an angle = given angle (α). Bisect arc BC in P. Join PO, and produce it to meet circumference in A. Join AB, AC.

BAC is the triangle required.

Construct a triangle, given the base, vertical angle, and sum of sides.



Let SK be the base, β the given angle, and xy a straight line equal to the sum of the sides. On SK make a segment of a circle SOK which will contain an angle $= \beta$.

Suppose SOK is the required Δ. Then SO + OK = the straight line xy.

Produce SO to A, so that SA $= k + s$. Join AK.

Since OA = OK, $\angle OKA = \angle A$

and exterior $\angle SOK\ (\beta) = \angle A + \angle OKA$

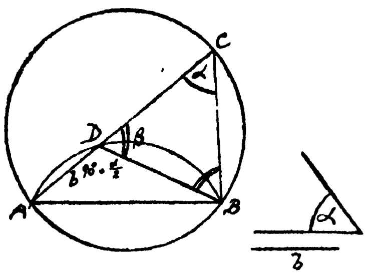
$= 2\angle A$

$\therefore \quad \angle A = \frac{1}{2}\beta.$

Construction.—On SK describe a segment of a circle SOK that will contain an angle equal to β, and on SK describe a segment SAK that will contain an angle equal to $\frac{\beta}{2}$.

With centre S, radius xy, draw an arc, cutting the latter circle in A. Join AS and let it cut smaller ⊙ in O. Join OK, AK.

Construct a triangle, given base, vertical angle, and difference of the sides.



Let AB be the given base, a the given vertical angle, and b the difference of the other sides.

Suppose ABC is the Δ required.

Cut off CD = CB. Then AD is the difference of the sides AC and CB, and AD $= b$.

Because CD = CB, $\angle CDB = \angle CBD = \beta$ (say).

But $\angle C + \angle CDB + \angle CBD = 180°$

$\therefore \quad a + \beta + \beta = 180°$

i.e. $\quad a + 2\beta = 180°$

$\therefore \quad 2\beta = 180° - a$

or $\quad \beta = 90° - \frac{a}{2}$

Now $\angle BDC$ (*i.e.* β) $= 180° - \angle ADB$

$\therefore \quad \angle ADB = 180° - \beta$

$= 180° - \left(90° - \frac{a}{2}\right)$

$= 180° - 90° + \frac{a}{2}$

$= 90° + \frac{a}{2}.$

Construction.—On AB describe a segment of a circle that will contain an angle equal to $90° + \frac{a}{2}$.

With centre A, radius b, cut this segment in D.

On AB describe a segment of a circle that will contain an angle equal to a.

Produce AD to meet the large circle in C. Join CB, DB.

ABC is the required triangle.

Proof.—

$\angle BDC = 180° - \angle BDA$

$= 180° - \left(90° + \frac{a}{2}\right)$

$= 180° - 90° - \frac{a}{2}$

$= 90° - \frac{a}{2}.$

Again, exterior $\angle BDA$ of $\Delta BCD = \angle C + \angle CBD$.

i.e. $\quad 90° + \frac{a}{2} = \angle C + \angle CBD$

$= a + \angle CBD$

$\therefore \quad \angle CBD = 90° + \frac{a}{2} - a$

$= 90° - \frac{a}{2}$

But $\angle BDC = 90° - \frac{a}{2}$

$\therefore \quad \angle BDC = \angle CBD$

and $\quad$ CD = CB (Euclid, I, 6).

Then AC − CB = AC − CD

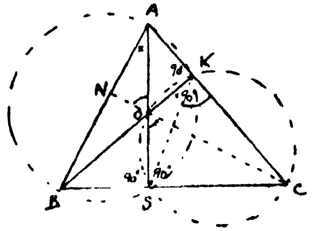
= AD

$= b$, *i.e.* the difference of the sides

and $\quad \angle C = a$.

Hence on base AB the ΔABC has been described, having $\angle C$ = given angle a, and difference of sides AC and CB $= b$.

The Normals drawn from the vertices of a triangle to the opposite sides are concurrent.



Let ABC be a triangle, and let AS, BK be normals from vertices A and B to opposite sides, and let them intersect at O.

Join CO, and produce CO to meet AB in N.

Then CN is perpendicular to AB.

Proof.—Join KS.

Then, since $\angle OKC = \angle OSC = 90°$

OKCS are concyclic points.

And because $\angle$s SOC and SKC stand on the same arc SC of the circle OKCS,

$\angle SKC = \angle SOC$

$= \angle NOA$, the vertically opposite angle.

Again, since $\angle AKB = \angle ASB = 90°$, and these angles stand on the same base AB, AKSB are concyclic.

Hence $\angle BAS = \angle BKS$, standing on the same arc BS.

$\therefore \quad \angle BAS + \angle NOA = \angle BKS + \angle SKC$
$= 90°$

But $\quad \angle BAS + \angle NOA + \angle ANO = 180°$

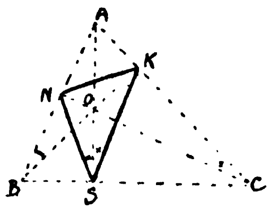
$\therefore \quad 90° + \angle ANO = 180°$

$\therefore \quad \angle ANO = 90°$

i.e. CN is perpendicular to AB.

Note.—The point O is called the orthocentre of the $\triangle ABC$; and if the feet of the perpendiculars CN, AS, BK be joined, the $\triangle SNK$ is called the pedal or orthocentric triangle.

It can be shown that *the normals from the vertices to the opposite sides of a triangle bisect the angles of the pedal triangle.*



Let NKS be the pedal triangle of $\triangle ABC$.

Then, since $\angle OKC = \angle OSC = 90°$,

O, K, C, S are concyclic

$\therefore \quad \angle OSK = \angle OCK$ in the same segment.

Again, since $\angle BNO = \angle BSO = 90°$,

N, O, S, B are concyclic

$\therefore \quad \angle NBO = \angle NSO$ in the same segment.

Now $\angle NCA = \angle ANC - \angle NAC$
$= 90° - \angle NAC$
$= \angle AKB - \angle NAC$
$= \angle ABK$

$\therefore \quad \angle OSK = \angle NSO$, *i.e.* $\angle NSK$ is bisected by AS. Similarly $\angle$s SNK and NKS are bisected by CN and BK.

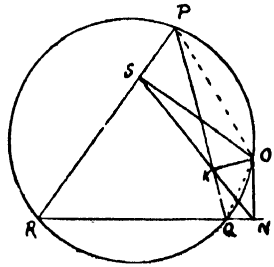
Since $\angle OSB = 90° = \angle OSC$

and $\angle OSN = \angle OSK$

$\therefore \angle NSB = \angle KSC$

i.e. *the sides of a pedal triangle are equally inclined to the side of the containing triangle in which they meet.*

Simson's Line.—*The feet of the normals drawn to the three sides of a triangle from any point on the circumcircle are collinear.*



Let O be any point on the circumcircle of $\triangle PQR$, and let OS, OK, ON be the normals to the sides.

Then the points S, K, N are collinear (lie in a straight line).

Join KS, KN, OP, OQ.

Proof.—Since $\angle OKQ = \angle ONQ = 90°$,

K, O, N, Q are concyclic

$\therefore \quad \angle OKN = \angle OQN$ in the same segment

$=$ the supplement of $\angle OQR$.

But the supplement of $\angle OQR$ is $\angle RPO$, since POQR is a cyclic quadrilateral.

$\therefore \quad \angle OKN = \angle RPO.$

Again, since $\angle PSO = \angle PKO$, P, S, K, O are concyclic.

$\therefore \quad \angle SPO$ is the supplement of $\angle SKO$.

But $\angle SPO = \angle OKN$,

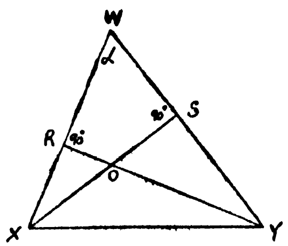
$\therefore \quad \angle OKN$ is the supplement of $\angle SKO$.

i.e. SK and KN are in one straight line.

Hence S, K, N are collinear.

The line SKN is known as Simson's Line or the Pedal Line.

In a triangle with a vertical angle α and a given base XY, find the locus of the orthocentre.



Let WXY be the $\triangle$ and O the orthocentre.

Then, since $\angle WRO = \angle WSO = 90°$,

W, S, O, R are concyclic.

$\therefore \quad \angle W + \angle ROS = 180°$

i.e. $a + \angle ROS = 180°$

$\therefore \quad \angle ROS = 180° - a$

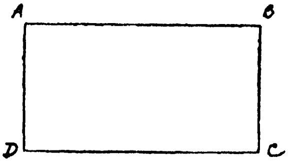
But $\quad \angle ROS = \angle XOY$

$\therefore \quad \angle XOY = 180° - a.$

The locus of O, therefore, is a segment of a circle described on XY and containing an angle $180° - a$.

Euclid, Book II

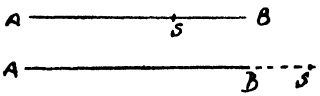
Squares and Rectangles.—*Definitions.*—(1) The rectangle ABCD can be drawn if the sides AB, AD are known. Hence rectangle is said to be contained by AB, AD. Hence it may be called the rectangle AB.CD (*i.e.* AB × CD).



(2) If a point be taken in a straight line, it divides the straight line into segments. If the point S is in the straight line AB, AB is said to be divided internally at S.

Here AB = AS + SB

= *sum of segments.*

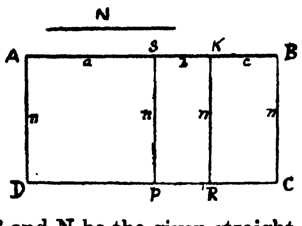


If the point S is on AB produced, AB is said to be divided externally at S.

Here AB = AS − SB

= *difference of segments.*

If of two straight lines one is divided into any number of parts, the rectangle contained by the two lines is equal to the sum of the rectangles contained by the undivided line and the parts of the divided line. (Euclid, II, 1.—A Theorem.)



Let AB and N be the given straight lines, and let AB be divided into any number of parts AS, SK, KB.

Let N measure n units, AS a units, SK b units, KB c units.

Then AB $= a + b + c$ units.

It is required to prove

rect. AB.N = rect. AS.N + rect. SK.N + rect. KB.N

i.e. $(a+b+c)n = an + bn + cn.$

Construction.—At A draw AD = N and normal to AB. Through D draw DC parallel to AB, and through S, K, B draw SP, KR, BC parallel to AD and meeting DC in P, R, C.

Proof.—Fig. AC = fig. AP + fig. SR + fig. KC, and AP = rect. AS.AD = rect. AS.N $= an$

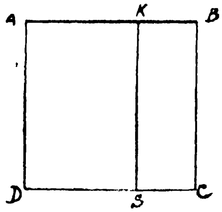
SR = rect. SK.SP = rect. SK.AD = rect. SK.N $= bn$

KC = rect. KB.BC = rect. KB.AD = rect. KB.N $= cn.$

and whole AC = rect. AB.AD = rect. AB.N $= (a+b+c)n.$

Hence rect. AB.N = rect. AS.N + rect. SK.N + rect. KB.N, or $(a+b+c)n = an + bn + cn.$

Special Case I.—When AB is divided into two segments AK and KB only, and the undivided line AD = AB. *The square on a given straight line is equal to the sum of the rectangles contained by the whole line and each of the segments.* (Euclid, II, 2.)



Here fig. AC = fig. AS + fig. KC

i.e. AB^2 = rect. AK.AD + rect. KB.BC

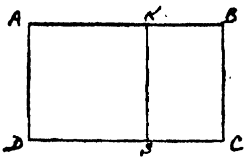
= rect. AK.AB + rect. KB.AB

or thus AB^2 = AB.AB

= AB.(AK + KB)

= AB.AK + AB.KB.

Special Case II.—When AB is divided into two segments AK.KB, and one segment AK equals the undivided line.



Here fig. AC = fig. AS + fig. KC

i.e. rect. AB.AD = rect. AK.AD + rect. KB.BC

i.e. rect. AB.AK = rect. AK.AK + rect. KB.AK

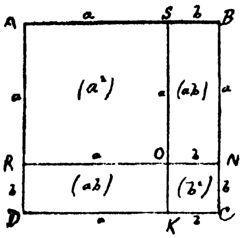
= square on AK + rect. KB.AK

or AB.AK = (AK + KB)AK

= AK.AK + AK.KB

$= AK^2 + AK.KB.$

If a straight line is divided internally *at any point, the square on the whole line is equal to the sum of the squares on the segments, plus twice the rectangle contained by the segments.* (Euclid, II, 4.—A Theorem.)



Let AB be the straight line divided internally at S.

It is required to prove that

$$AB^2 = AS^2 + SB^2 + 2 \text{ rec. } AS.SB$$

or, if AS measure a units, and SB b units $(a+b)^2 = a^2 + b^2 + 2ab$.

Construction.—On AB describe the square ABCD. From AD cut off $AR = AS$. Through R draw RN parallel to AB, and through S draw SK parallel to AD, and let RN and SK intersect at O.

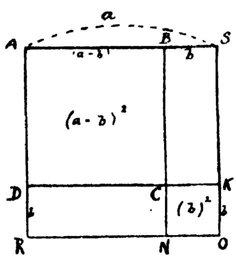
Proof.—The fig. AC = fig. AO + fig. OC + fig. SN + fig. RK

i.e. square on AB = square on AS + square on ON or SB + rect. SB.BN + rect. RO.RD

or $AB^2 = AS^2 + SB^2 +$ rect. SB.AS + rect. AS.SB
$= AS^2 + SB^2 + 2$ rect. AS.SB

that is $(a+b)^2 = a^2 + b^2 + 2ab$.

If a straight line be divided externally *at any point, the square on the given line is equal to the sum of the squares on its segments* minus *twice the rectangle contained by the segments.* (Euclid II, 7.—A Theorem.)



Let AB be divided externally at S into two segments AS, BS.

It is required to prove

$$AB^2 = AS^2 + BS^2 - 2AS.BS$$

or if AS measure a units, and BS b units $(a-b)^2 = a^2 + b^2 - 2ab$.

Construction.—On AS describe a square ASOR. From AR cut off $AD = AB$, and through D and B draw DK, BN parallel to AS and AR respectively, and let DK and BN intersect in C.

Proof.—The fig. AC = fig. AO − (fig. SN + fig. CR).

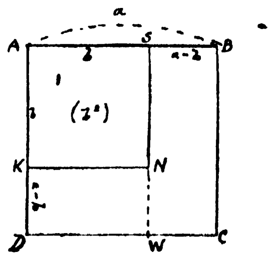
To each term in the right side of the equation add fig. CO.

Then AC = fig. AO + fig. CO − (fig. SN + fig. CR + fig. CO)
= AO + CO − (SN + KR)
= AO + CO − (rect. SO.SB + rect. RO.DR)
= AO + CO − (rect. AS.SB + rect. AS.SB)
= AO + CO − 2AS.BS

i.e. $AB^2 = AS^2 + BS^2 - 2AS.BS$

or $(a-b)^2 = a^2 + b^2 - 2ab$.

The difference of the squares on two straight lines is equal to the rectangle contained by their sum and difference. (Euclid, II, 5 and 6.—A Theorem.)



Let AB, AS be the given straight lines and let them be placed in the same straight line.

It is required to prove

$$AB^2 - AS^2 = (AB + AS)(AB - AS)$$

or if AB measure a units, and AS b units

$$a^2 - b^2 = (a+b)(a-b).$$

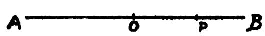
Construction.—On AB describe the square ABCD, and on AS describe the square ASNK. Produce SN to meet DC in W.

Proof.—$AB^2 - AS^2$ = fig. AC − fig. AN
= fig. SCK
= fig. SC + fig. KW
= SB.BC + KD.KN
= SB.AB + SB.AS
= SB(AB + AS)

i.e. $a^2 - b^2 = (a-b)(a+b)$.

Corollary.—If a straight line is bisected and divided into two unequal segments, the rectangle contained by these segments is equal to the difference of the squares on half the line and on the line between the points of section.

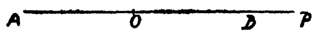
Case I.—Let AB be bisected in O and divided *internally* into two unequal segments at P.



Then rect. $AP.PB = AO^2 - OP^2$.

Proof.— $AP.PB = (AO + OP)(OB - OP)$
$= (AO + OP)(AO - OP)$
$= AO^2 - OP^2$.

Case II.—Let AB be bisected in O and divided *externally* into two unequal segments AP, PB.



Then rect. $AP.PB = OP^2 - AO^2$.

Proof.— $AP.PB = (OP+AO)(OP-OB)$
$= (OP+AO)(OP-OA)$
$= OP^2 - AO^2$.

If a straight line be bisected and also divided into two unequal segments, the sum of the squares on the unequal segments is equal to twice the sum of the squares on half the line and on the line between the points of section. (Euclid, II, 9 and 10. —A Theorem.)

Let AB be the given straight line bisected in K and divided into two unequal segments at S. It is required to prove

$$AS^2 + SB^2 = 2(AK^2 + KS^2).$$

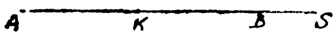
Case I.—When AB is divided *internally* at S.

$AS^2 = AK^2 + KS^2 + 2AK.KS$ (Euclid, II, 4)

$SB^2 = KB^2 + KS^2 - 2KB.KS$ (Euclid, II, 7)

$\therefore AS^2 + SB^2 = AK^2 + KB^2 + 2KS^2 + 2AK.KS - 2KB.KS$
$= AK^2 + AK^2 + 2KS^2 + 2AK.KS - 2AK.KS$
$= 2AK^2 + 2KS^2$
$= 2(AK^2 + KS^2)$.

Case II.—When AB is divided *externally* at S.

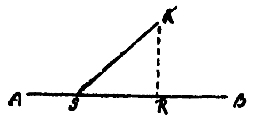


$AS^2 = AK^2 + KS^2 + 2AK.KS$ (Euclid, II, 4)

$SB^2 = KS^2 + KB^2 - 2KS.KB$ (Euclid, II, 7)

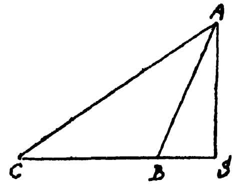
$\therefore AS^2 + SB^2 = AK^2 + KB^2 + 2KS^2 + 2AK.KS - 2KS.AK$
$= AK^2 + AK^2 + 2KS^2$
$= 2(AK^2 + KS^2)$.

Definition.—If SK is a straight line inclined to another straight line AB, and if normal KR be dropped from K to AB, the part SR is known as the *projection* of SK on AB.



In an obtuse-angled triangle, the square on the side subtending the obtuse angle is equal to the sum of the squares on the other two sides plus ***twice the rectangle contained by one of those sides and the projection of the other side upon it.*** **(Euclid, II, 12.—A Theorem.)**

Let $\triangle ABC$ be obtuse-angled at B, and let BS be the projection of BA upon CB produced (*i.e.* AS is a normal on CS).

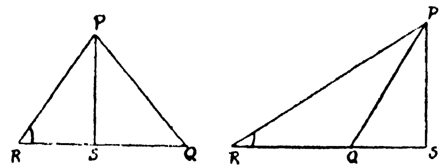


It is required to prove

$$AC^2 = CB^2 + BA^2 + 2CB.BS.$$

Proof.—$AC^2 = CS^2 + SA^2$ (Euclid, I, 47)
$= (CB^2 + BS^2 + 2CB.BS) + SA^2$
$= CB^2 + 2CB.BS + (BS^2 + SA^2)$
$= CB^2 + 2CB.BS + AB^2$
$= CB^2 + BA^2 + 2CB.BS$.

In every triangle the square on the side subtending an acute angle is equal to the sum of the squares on the sides containing that angle, minus *twice the rectangle contained by one of these sides and the projection of the other side upon it.* (Euclid, II, 13.—A Theorem.)



Let $\triangle PQR$ be acute-angled at R.
It is required to prove that

$$PQ^2 = RP^2 + RQ^2 - 2RQ.RS$$

RS being the projection of RP on RQ.

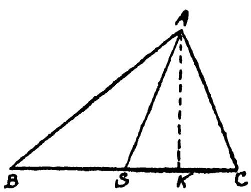
Proof.— $SQ = RQ - RS$
$SQ^2 = (RQ - RS)^2$
$= RQ^2 - 2RQ.RS + RS^2$.

To each side of the equation add PS^2.

Then $SQ^2 + PS^2 = RQ^2 - 2RQ.RS + RS^2 + PS^2$

or $PQ^2 = RQ^2 - 2RQ.RS + RP^2$
$= RP^2 + RQ^2 - 2RQ.RS$.

Prove that in $\triangle ABC$ *the sum of the squares on* AB *and* AC *is equal to twice the square on half* BC, *together with twice the square on the median* AS, *bisecting* BC.



From A draw AK perpendicular to BC.

Then $AB^2 + AC^2 = 2BS^2 + 2SA^2$.

Proof.—In $\triangle ABS$, by Euclid, II, 12

$$AB^2 = BS^2 + SA^2 + 2BS.SK \qquad (1)$$

In $\triangle ACS$, by Euclid, II, 13

$$AC^2 = CS^2 + SA^2 - 2CS.SK$$
$$= BS^2 + SA^2 - 2BS.SK \qquad (2)$$

Adding (1) and (2)

$$AB^2 + AC^2 = 2BS^2 + 2SA^2$$

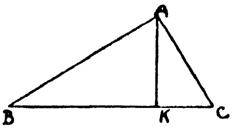
In above $\triangle ABC$ prove

$$AB^2 - AC^2 = 2BC.SK.$$

Subtracting (2) from (1) above

$$AB^2 - AC^2 = 4BS.SK$$
$$= 2 \times 2BS \times SK$$
$$= 2BC.SK.$$

ABC *is a triangle right-angled at* A. AK *is the normal on* BC. *Prove* AK^2 = *rectangle* BK.KC.



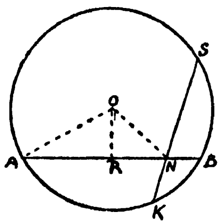
Proof.—

$$2AK^2 = (AB^2 - BK^2) + (AC^2 - KC^2)$$
$$= (AB^2 + AC^2) - BK^2 - KC^2$$
$$= BC^2 - BK^2 - KC^2$$
$$= (BK^2 + KC^2 + 2BK.KC) - BK^2 - KC^2$$
$$= 2BK.KC.$$

Divide each side by 2,

$$\text{and } AK^2 = BK.KC.$$

If two chords of a circle intersect at a point, the rectangles contained by their segments are equal. (Euclid, III, 35 and 36.—A Theorem.)



Case I.—When the chords intersect within the circle.

Let AB and SK, two chords in ⊙ ASB, intersect in N.

It is required to prove rect. AN.NB = rect. SN.NK.

Join centre O to A and N, and from O draw OR perpendicular to AB. OR bisects AB.

Note.—We must show that AN.NB is equal to some *constant.* AO is a constant, because equal to radius r, and ON is a constant, because points O and N are fixed.

Proof.—Rect. AN.NB = (AR + RN)(RB − RN)

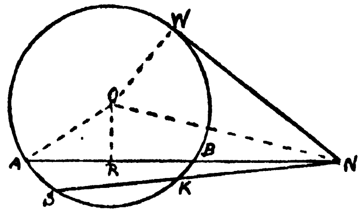
Rect. AN.NB = (AR + RN)(AR − RN)

$$= AR^2 - RN^2$$
$$= (AO^2 - OR^2) - (ON^2 - OR^2)$$
$$= AO^2 - OR^2 - ON^2 + OR^2$$
$$= AO^2 - ON^2$$
$$= r^2 - ON^2.$$

Similarly SN.NK may be proved equal to $r^2 - ON^2$.

Hence rect. AN.NB = rect. SN.NK.

Case II.—When the chords intersect outside the circle.



Proof.

Rect. AN.NB = (AR + RN)(RN − RB)

$$= (RN + AR)(RN - AR)$$
$$= RN^2 - AR^2$$
$$= (ON^2 - OR^2) - (AO^2 - OR^2)$$
$$= ON^2 - OR^2 - AO^2 + OR^2$$
$$= ON^2 - AO^2$$
$$= ON^2 - r^2.$$

Similarly rect. SN.NK = $ON^2 - r^2$.

∴ rect. AN.NB = rect. SN.NK.

Euclid, III, 36, goes on to show that each rectangle is equal to the square on the tangent from N.

Let NW be a tangent to ⊙ASB.

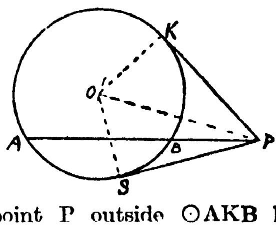
Join OW.

Then ∠OWN = 90°.

Now $WN^2 = ON^2 - OW^2$ (Euclid, I, 47)

$$= ON^2 - r^2$$
$$= \text{rect. } AN.NB = \text{rect. } SN.NK.$$

If from a point outside a circle two straight lines be drawn, one of which cuts the circle, and the other meets it; and if the rectangle contained by the former and the part of it outside the circle is equal to the square on the latter, then the latter is a tangent to the circle. (Euclid, IV, 37.—A Theorem.)



From point P outside ⊙AKB let straight lines PBA and PK be drawn, the former cutting the circle at B and A, and the latter touching it at K.

And let rect. PB.PA = PK.²

It is required to prove PK a tangent to AKB.

Proof.—From P draw a tangent PS

Then $PB.PA = PS^2$ (Euclid, III, 36)

but $PB.PA = PK^2$ by hypothesis.

∴ $PS^2 = PK^2$

∴ $PS = PK$

Find O, the centre of $\odot$AKB.

Join OK, OP, OS.

In $\triangle$s OPS and OPK

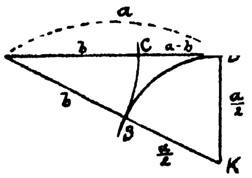
three sides of one = three sides of the other

$\therefore$ $\triangle$OPS = $\triangle$OPK (Euclid, I, 8)

$\therefore$ $\angle$K = $\angle$S = 90°, since PS is a tangent

$\therefore$ PK is a tangent to $\odot$AKB.

Medial Section.—*Divide a given straight line so that the rectangle contained by the whole and one part may be equal to the square on the other part.*



Case I.—When the line is to be divided internally.

Let AB be the line to be divided, and let it measure a units.

Construction.—At B draw the normal BK $= \frac{a}{2}$ units. Join AK.

With centre K, radius $\frac{a}{2}$ cut off, on KA, KS, and with centre A, radius AS cut off on AB, AC, and let AS = AC = b units.

Then AB.BC = AC².

Note that BC = $a - b$ units.

Proof.—a^2 = AB² = AK² − BK² (Euclid, I, 47)

$$= (AK+BK)(AK-BK)$$

$$= \left(b+\frac{a}{2}+\frac{a}{2}\right)\left(b+\frac{a}{2}-\frac{a}{2}\right)$$

$$= (b+a)(b)$$

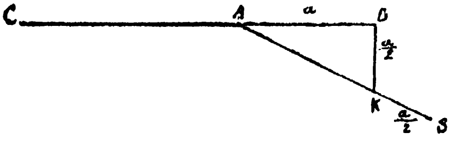
$$= b^2 + ab.$$

Subtract ab from each side, and $a^2 - ab = b^2$.

Factorise, and $a(a-b) = b^2$

i.e. AB.BC = AC².

Case II.—When the line is to be divided externally.



As before, draw BK perpendicular to AB and equal to $\frac{a}{2}$. Join AK and produce it to S, so that KS = KB $= \frac{a}{2}$.

With centre A, radius AS cut AB produced in a negative sense in C.

Then AB.BC = AC².

Let AC = AS = b units in length.

Proof.—a^2 = AB² = AK² − BK²

$$= (AK+BK)(AK-BK)$$

$$= \left(b-\frac{a}{2}+\frac{a}{2}\right)\left(b-\frac{a}{2}-\frac{a}{2}\right)$$

$$= b(b-a)$$

$$= b^2 - ab.$$

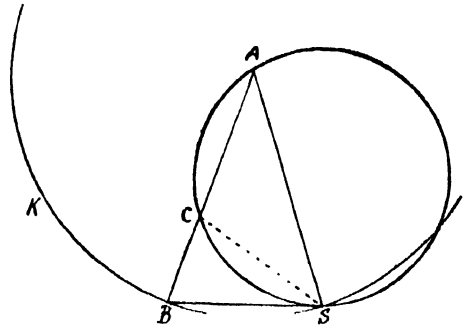
Hence $b^2 = a^2 + ab$

$$= a(a+b)$$

AC² = AB(AB + AC)

= AB.BC.

Draw an isosceles triangle having each of the base angles double of the vertical angle (Euclid, IV, 10.—A Problem.)



Construction.—Take any straight line AB and divide it in medial section at C, so that AC² = AB.BC.

With centre A radius AB, describe $\odot$KBS. With centre B, radius AC, cut circumference of $\odot$KBS in S.

Join BS, SA.

ABS is the required triangle.

Proof.—Join SC, and describe $\odot$ACS passing through A, C, S.

Since BA.BC = AC² = BS²

BS is a tangent to $\odot$ACS (Euclid, III, 37).

Hence $\angle$BSC = $\angle$A in alternate segment (Euclid, III, 32).

To each add $\angle$ASC.

Then $\angle$A + $\angle$ASC = $\angle$BSC + $\angle$ASC

= $\angle$ASB

= $\angle$B (Euclid, I, 5).

But exterior $\angle$BCS of $\angle$ACS = sum of interior opposite angles

= $\angle$A + $\angle$ASC

= $\angle$B.

$\therefore$ SB = SC (Euclid, I, 6)

= AC.

Hence $\triangle$ACS is isosceles.

$\therefore$ $\angle$A = $\angle$ASC.

Since $\angle$B = $\angle$BCS

= $\angle$A + $\angle$ASC

= 2$\angle$A

$\angle$ASB = 2$\angle$A.

Hence $\triangle$ABS has each of its base angles double of the vertical angle.

Note.—The above construction can be done practically by calculating the size of vertical angle a. Angles of $\triangle$ABS are a, $2a$, $2a$.

Now $a + 2a + 2a = 180°$

i.e. $5a = 180°$

$\therefore$ $a = 36°$.

TRIGONOMETRY

Introduction.—Trigonometry (from the Greek *trigonon*, a triangle; *metria*, measurement) is a branch of Pure Mathematics, and deals chiefly with the relations which exist between the sides and angles of a triangle.

A triangle drawn on a plane surface is called a *plane* triangle, while one drawn on a sphere, and which will have its sides curved, each side being part of a circle, is termed a *spherical* triangle. The subject is thus naturally divisible into two branches—Plane Trigonometry and Spherical Trigonometry. The former branch is the simpler of the two, and its study will naturally precede the latter. In the following pages I shall confine myself entirely to Plane Trigonometry.

Trigonometry finds innumerable applications in problems that require mathematical treatment, and is indispensable in land surveying, a process carried out in the following manner. We will suppose that the adjoining figure represents

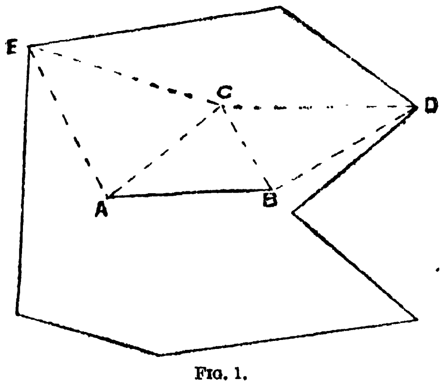


FIG. 1.

a district to be surveyed. A line AB, chosen on a flat surface or plane, is first very carefully measured. This line is called the *base* line. A signal-post is set up at C, or else some prominent landmark, such as a tree or church steeple, is chosen for the purpose. By carefully measuring the angles BAC and ABC with a theodolite, an imaginary triangle ACB is formed. Now every triangle consists of six elements—three sides and three angles—and knowing any three of these elements,* the others can then be calculated by methods described towards the end of this article. Hence, having measured the line AB and the angles BAC and ABC, the lengths AC and BC and the angle ACB can then be calculated, and either of the lines AC, BC, can then be used as a fresh base for other triangles, such as BCD, ACE. This process is repeated until the whole of the district has been covered by such a series of triangles. These triangles are then subdivided into a number of smaller triangles, and thus an accurate map of the district can be constructed. The last side of the last triangle formed is carefully measured, and its measured length compared with its calculated length, as a check on the degree of accuracy with which the survey has been carried out.

* At least *one* side must form one of the known elements.

In the Ordnance Survey of Great Britain and Ireland, the base line, 7 miles in length, was measured on Salisbury Plain; another line, nearly 8 miles long, was measured near Lough Foyle in Ireland; and the difference between the length of the line on Salisbury Plain, as actually measured and as calculated from the Lough Foyle base, was less than 5 inches.

Since the world is a large sphere, any triangle drawn on its surface is necessarily spherical, but, provided the lengths of the sides do not exceed a couple of miles in length, such a triangle is practically plane, and in such a survey the results of Plane Trigonometry can be applied without fear of any appreciable error. Where larger triangles are used, the formulæ of Spherical Trigonometry—which, however, closely resemble those of Plane Trigonometry—must be applied.

Angles.—Euclid defines an angle as "the inclination of two straight lines to one another, which meet but are not in the same straight line." This definition is now practically discarded, and a different point of view is adopted. Of the two straight lines AB and AC, which form an angle BAC (see Fig. 2), one of them—

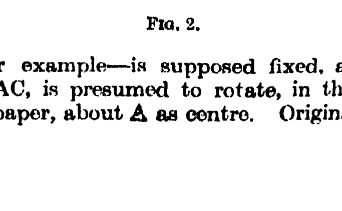


FIG. 2.

AB, for example—is supposed fixed, and the other, AC, is presumed to rotate, in the plane of the paper, about A as centre. Originally the

two lines coincided, and when AC has reached the position indicated in the figure it is said *to have described the angle BAC.*

According to this view, it is evident: (1) That the size of the angle so formed is not affected by the lengths of the lines AB and AC which form the angle, and only depends on the *amount of rotation* of the line AC. (2) The line AC might have reached the position indicated in the figure either by rotating in an anti-clockwise direction (indicated by the arrow a) or by rotating in the same direction as the hands of a clock (indicated by the arrow b). In the former case the amount of rotation is less than in the latter. Hence the figure illustrates *two* possible angles, marked α and β, of which α is the smaller. (3) Some convention is necessary which will indicate the direction in which the movable line has rotated. The one adopted is to call the anti-clockwise rotation *positive*, and the clockwise rotation *negative*. The angle α is therefore a positive angle, and β a negative one (written $-\beta$). (4) Not only do we obtain positive and negative angles, but there is no limit to the size of an angle. The Euclidian definition admits neither negative angles nor angles greater than two right angles. (5) In the course of rotation of the line AC, the end C describes an arc of a circle, of which AC is a radius.

Measurement of Angles.—There are three methods of measuring angles, but we need only consider two of them.

(1) *The Sexagesimal or English Measure.*—In this system, when the end C of the rotating line AC has described a complete circle, it is said to have described an angle of 360 degrees (written 360°); when it has described half of a circle, so that the lines AB and AC are in one and the same straight line, the angle between them is 180°, and so on. An angle of 1 degree is thus obtained when one of the two lines forming the angle has rotated away from the other through $\frac{1}{360}$th of a circle. A degree is further subdivided into 60 minutes, and each minute again into 60 seconds—a minute being denoted by (′) and a second by (″). 10° 15′ 27″ therefore reads 10 degrees 15 minutes 27 seconds. It is to be noted that this system of measuring angles is an arbitrary one—there is no reason whatever for choosing the number 360 as the one into which the circle is to be divided.

(2) *Circular Measure.*—Since the size of an angle depends on the amount of rotation of the line AC, the length of the arc BC (see last figure) supplies a natural measure of the angle BAC, *provided* the radius AC is assumed to be always of the *same* length for all angles. This length is taken as unit length, so that in circular measure, unit angle is such an angle that the length of the arc BC is unity, when described by the end C of a rotating line AC of unit length; or what amounts to exactly the same thing, a unit angle is such that the *ratio* of the arc BC to the radius AC is unity. This unit angle is called a *radian*, and being a logical, not an arbitrary, unit, it is the one adopted in theoretical mathematics, so that by "an angle θ" is meant an angle of θ radians.

The ratio,

$$\frac{\text{the length of the circumference of a circle}}{\text{the length of its diameter}},$$

has been calculated to very many decimal places by methods which will be found explained in a text-book on Higher Trigonometry. We have no *numerical* expression whatever to represent it *exactly*; it is therefore said to be *incommensurable*. The custom has arisen of denoting the *exact* value of this ratio by the Greek letter π, which thus represents a number extending to many hundreds of decimal places, but which in practice is taken as *approximately* equal to 3·14159, or $\frac{22}{7}$, or $\frac{355}{113}$.

Since

$$\frac{\text{the length of the circumference of a circle}}{\text{the length of its diameter}}$$

$$=\pi=\frac{\text{the length of the circumference}}{2\times\text{the length of the radius}}$$

$$\therefore\ \frac{\text{length of circumference}}{\text{length of radius}},$$ which corresponds to an angle of 360° in the sexagesimal measure $=2\pi$ radians.

Hence π radians $=180°$, an equation which supplies a basis of calculation for expressing an angle in radians when its value in degrees is known, and *vice versa*.

Reckoning π as equal to $\frac{22}{7}$, we have

$$\text{one radian}=\frac{7\times180^\circ}{22}=57^\circ\ 16'\ 22''\ \text{nearly.}$$

Reckoning π as equal to $\frac{355}{113}$, we have

$$\text{one radian}=\frac{113\times180^\circ}{355}=57^\circ\ 17'\ 44{\cdot}79''.$$

This last value only differs from the true value by ·01″.

Given an angle in terms of radians, it is only a question of working a simple proportion to find its value in terms of degrees; and conversely, given the angle in degrees, it is equally easy to express it in radians.

The Trigonometrical Ratios.—For purposes of direct practical measurement, neither of the two methods just described are suitable. Trial will at once convince the reader that it is not easy to measure, with any great degree of accuracy, either the length of a given arc of a circle or the fraction which such an arc forms of the whole circle. There are, however, certain other quantities which remain constant for any given angle,

which are easily measurable, and between which relations exist which lend themselves to mathematical treatment.

Let BAC represent *any* angle, which we will call θ. From *any* point P in the line AC,

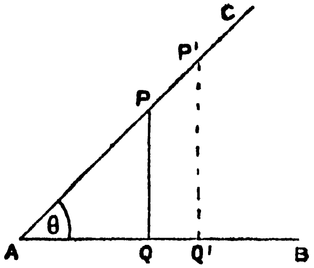


FIG. 3.

supposed to have rotated into its present position from the position occupied by AB, draw a line PQ perpendicular to AB. From any other point P′ draw another perpendicular P′Q′. A knowledge of Euclid, Book VI, in which the properties of similar triangles are discussed, will enable the reader to prove for himself that $\frac{PQ}{AP}=\frac{P'Q'}{AP'}$, that $\frac{AQ}{AP}=\frac{AQ'}{AP'}$, and $\frac{PQ}{AQ}=\frac{P'Q'}{AQ'}$. In other words, the *ratios* $\frac{PQ}{AP}$, $\frac{AQ}{AP}$, $\frac{PQ}{AQ}$ remain constant for all positions of P, and only depend on the size of the angle. A little consideration will also show that it is indifferent whether the line AB or AC is considered as the fixed line. If AC

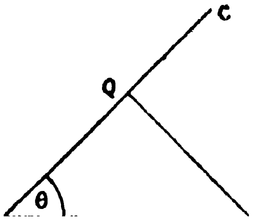


FIG. 4.

is considered fixed, the figure is a little different in appearance, (Fig. 4) but the ratios $\frac{PQ}{AP}$, $\frac{AQ}{AP}$, $\frac{PQ}{AQ}$ still have the same values, depending, as they do, merely on the size of the angle θ. It is further to be noted that the values of these ratios are independent of the measure, whether sexagesimal or circular, adopted for the angle.

Now APQ (Fig. 3 or 4) forms a right-angled triangle, of which AP is the hypotenuse. Calling PQ, the side opposite the angle θ, the *perpendicular* and AQ the *intercept*, that being the distance along the fixed line intercepted by the perpendicular PQ, the above ratios may be expressed as $\frac{\text{perpendicular}}{\text{hypotenuse}}$, $\frac{\text{intercept}}{\text{hypotenuse}}$, $\frac{\text{perpendicular}}{\text{intercept}}$. These ratios are respectively called the *sine*, *cosine*, and *tangent* of the angle θ, and in practice these terms are abbreviated to *sin*, *cos*, and *tan*.

Sin θ, therefore, means the ratio $\frac{\text{perpendicular}}{\text{hypotenuse}}$, obtained by dropping a perpendicular from one of the lines forming the angle on to the other.

Similarly, $\cos\theta = \frac{\text{intercept}}{\text{hypotenuse}}$, and $\tan\theta = \frac{\text{perpendicular}}{\text{intercept}}$. The sine, cosine, and tangent of an angle are the three principal *trigonometrical ratios*, or, as they are frequently called, the *circular functions* of the angle; and the student must make himself thoroughly familiar with them before attempting to proceed further. They are as essential to trigonometry as the multiplication table is to arithmetic.

By inverting these three ratios we obtain three other important ratios.

The ratio $\frac{\text{hypotenuse}}{\text{perpendicular}}$ is called the *cosecant* (written *cosec*), and is equal to $\frac{1}{\text{sine}}$.

The ratio $\frac{\text{hypotenuse}}{\text{intercept}}$ is called the *secant* (written *sec*), and is equal to $\frac{1}{\text{cosine}}$.

The ratio $\frac{\text{intercept}}{\text{perpendicular}}$ is called the *cotangent* (written *cot*), and is equal to $\frac{1}{\text{tangent}}$.

It should further be noted that $(\sin\theta)^2$—*i.e.* $\left(\frac{\text{perpendicular}}{\text{hypotenuse}}\right)^2$—is written $\sin^2\theta$; $(\cos\theta)^3$—*i.e.* $\left(\frac{\text{intercept}}{\text{hypotenuse}}\right)^3$—is written $\cos^3\theta$, and so on for other powers.

We can at once find the values of the sine, cosine, and tangent of the angles 0°, 30°, 45°, 60°, and 90°, or (in circular measure), 0, $\frac{\pi}{6}$, $\frac{\pi}{4}$, $\frac{\pi}{3}$, and $\frac{\pi}{2}$.

For example :

For the angle 0°.—Since the lines AB and AC are coincident (in the adjoining figure they are

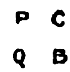


FIG. 5.

drawn nearly coincident for the sake of greater clearness), PQ = 0, and AQ = AP.

Hence $\sin 0° = \frac{PQ}{AP} = \frac{0}{AP} = 0$

$$\cos 0° = \frac{AQ}{AP} = \frac{AP}{AP} = 1$$

$$\tan 0° = \frac{PQ}{AQ} = \frac{0}{AQ} = 0$$

For the angle 30°, *or* $\frac{\pi}{6}$.—Let BAC be an angle of 30°. Draw PQ perpendicular to AB; then the angle APQ must be 60°, since the sum of

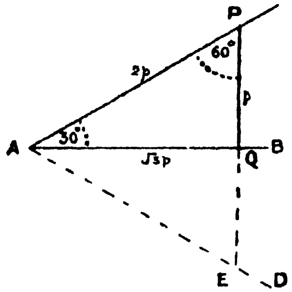


FIG. 6.

the angles of a triangle are together equal to two right angles (Euclid, Bk. I, Prop. 32). By drawing AD, so as to make another angle of 30° with AB, and producing PQ to meet AD in E, it is easily proved that if p is the length of PQ, then $AP = 2p$ and $AQ = \sqrt{3}p$.

Hence $\sin 30°$ or $\sin \frac{\pi}{6} = \frac{p}{2p} = \frac{1}{2}$

$$\cos 30° \text{ or } \cos \frac{\pi}{6} = \frac{\sqrt{3}p}{2p} = \frac{\sqrt{3}}{2} = \cdot 8660254$$

$$\tan 30° \text{ or } \tan \frac{\pi}{6} = \frac{p}{\sqrt{3}p} = \frac{1}{\sqrt{3}} = \cdot 5773503$$

The student should, as an exercise, find for himself the values of the principal trigonometrical ratios of the remaining angles mentioned above.

The cosecants, secants, and cotangents of all these angles can be at once found by inversion of the respective sines, cosines, and tangents.

Thus cosecant $30° = \frac{1}{\sin 30°} = \frac{2}{1}$, &c.

By methods beyond the scope of this article, the trigonometrical ratios have been enumerated for all the angles between 0° and 90°, and are to be found in any book of mathematical tables; so that, knowing the values of the sin, cos, &c., of any angle, the tables enable us to find the angle itself; and conversely, knowing the angle, the tables will supply us with any of the required ratios.

Thus, knowing that $\sin \theta = \cdot 5625645$, we turn to the tables and find that $\sin 34° \; 14' = \cdot 5625645$. Hence θ must be 34° 14′. Similarly for the other ratios.

Ratios of an Angle and its Complement.—In the trigonometrical ratios of any angle θ, it is always the sides of a right-angled triangle that are concerned. Hence the three angles of such a triangle are θ, 90°, and a third angle which must necessarily be equal to $(90° - \theta)$ or $\left(\frac{\pi}{2} - \theta\right)$, to make up the full complement of two right angles. For this reason the angles θ and $(90° - \theta)$ are each called the *complement* of the other. Important relations exist between the trigonometrical ratios of an angle and its complement:

$$\sin \theta = \frac{PQ}{AP}.$$

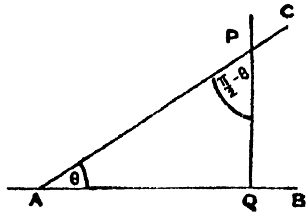


FIG. 7.

But $\frac{PQ}{AP} = \cos (\text{angle APQ}) = \cos \left(\frac{\pi}{2} - \theta\right)$.

Hence $\sin \theta = \cos \left(\frac{\pi}{2} - \theta\right)$

—*i.e.* the sine of an angle is equal to the cosine of its complement.

In the same manner the reader can prove for himself that:

$$\cos \theta = \sin \left(\frac{\pi}{2} - \theta\right); \; \tan \theta = \cot \left(\frac{\pi}{2} - \theta\right)$$

$$\cot \theta = \tan \left(\frac{\pi}{2} - \theta\right); \; \sec \theta = \operatorname{cosec} \left(\frac{\pi}{2} - \theta\right);$$

$$\operatorname{cosec} \theta = \sec \left(\frac{\pi}{2} - \theta\right).$$

Relations between the Trigonometrical Ratios of one or more Angles.—Besides these, other important relations (equations (i) to (xvi) below) exist between the trigonometrical ratios. The student *must* commit them to memory for ready use. From the last figure we have:

$$\frac{\sin \theta}{\cos \theta} = \frac{PQ}{AP} \Big/ \frac{AQ}{AP} = \frac{PQ}{AQ}.$$

But $\frac{PQ}{AQ} = \tan \theta.$

Hence $\tan \theta = \frac{\sin \theta}{\cos \theta}$ . . . . (i)

Also, since from Fig. 7, $PQ^2 + AQ^2 = AP^2$ [Euclid, Bk. I, Prop. 47], therefore, dividing throughout by AP^2, we have:

$$\frac{PQ^2}{AP^2} + \frac{AQ^2}{AP^2} = \frac{AP^2}{AP^2}$$

or $\sin^2 \theta + \cos^2 \theta = 1$ . . . . . . (ii)

Similarly, $\frac{PQ^2}{AQ^2}+\frac{AQ^2}{AQ^2}=\frac{AP^2}{AQ^2}$

or $\tan^2\theta+1=\sec^2\theta$. . . . (iii)

Similarly, $\frac{PQ^2}{PQ^2}+\frac{AQ^2}{PQ^2}=\frac{AP^2}{PQ^2}$

or $1+\cot^2\theta=\operatorname{cosec}^2\theta$ . . . (iv)

Equations (ii), (iii), and (iv) are merely the expression, in trigonometrical language, of the celebrated Proposition 47 of the first book of Euclid.

If α and β represent any two angles, the following relations hold between their trigonometrical ratios:

$\sin(\alpha+\beta)=\sin\alpha\cos\beta+\cos\alpha\sin\beta$ . . (v)

$\sin(\alpha-\beta)=\sin\alpha\cos\beta-\cos\alpha\sin\beta$ . . (vi)

$\cos(\alpha+\beta)=\cos\alpha\cos\beta-\sin\alpha\sin\beta$ . . (vii)

$\cos(\alpha-\beta)=\cos\alpha\cos\beta+\sin\alpha\sin\beta$ . . (viii)

For proofs of formulæ (v) to (viii) the reader should refer to a text-book.

From (v) and (vii) we get, by division:

$$\frac{\sin(\alpha+\beta)}{\cos(\alpha+\beta)}=\tan(\alpha+\beta)$$

$$=\frac{\sin\alpha\cos\beta+\cos\alpha\sin\beta}{\cos\alpha\cos\beta-\sin\alpha\sin\beta}$$

$$=\frac{\dfrac{\sin\alpha\cos\beta+\cos\alpha\sin\beta}{\cos\alpha\cos\beta}}{\dfrac{\cos\alpha\cos\beta-\sin\alpha\sin\beta}{\cos\alpha\cos\beta}}=\frac{\dfrac{\sin\alpha}{\cos\alpha}+\dfrac{\sin\beta}{\cos\beta}}{1-\dfrac{\sin\alpha}{\cos\alpha}\cdot\dfrac{\sin\beta}{\cos\beta}}$$

$$\therefore\ \tan(\alpha+\beta)=\frac{\tan\alpha+\tan\beta}{1-\tan\alpha\tan\beta}\quad . \ . \ . \ . \ . \ (ix)$$

Similarly, from (vi) and (viii) we get

$$\tan(\alpha-\beta)=\frac{\tan\alpha-\tan\beta}{1+\tan\alpha\tan\beta}\quad . \ . \ . \ . \ (x)$$

If $\alpha=\beta$, then (v) becomes
$\sin 2\alpha=2\sin\alpha\cos\alpha$;
or, writing θ for 2α:
$\sin\theta=2\sin\frac{\theta}{2}\cos\frac{\theta}{2}$ (an expression for the sine of an angle in terms of the sine and cosine of half the angle). (xi)

Similarly, if $\alpha=\beta$, then (vii) becomes

$$\begin{aligned}\cos 2\alpha&=\cos^2\alpha-\sin^2\alpha\\&=1-2\sin^2\alpha\ (\text{since }\cos^2\alpha=1-\sin^2\alpha,\text{ from ii})\\&=2\cos^2\alpha-1\ (\text{since }\sin^2\alpha=1-\cos^2\alpha,\text{ from ii})\end{aligned}$$

$$\left.\begin{aligned}\text{or}\quad\cos\theta&=\cos^2\frac{\theta}{2}-\sin^2\frac{\theta}{2}\\&=1-2\sin^2\frac{\theta}{2}\\&=2\cos^2\frac{\theta}{2}-1\end{aligned}\right\}\quad (xii)$$

Dividing (xi) by (xii) we get:

$$\tan 2\alpha=\frac{\sin 2\alpha}{\cos 2\alpha}=\frac{2\sin\alpha\cos\alpha}{\cos^2\alpha-\sin^2\alpha}$$

$$=\frac{\dfrac{2\sin\alpha\cos\alpha}{\cos^2\alpha}}{\dfrac{\cos^2\alpha-\sin^2\alpha}{\cos^2\alpha}}=\frac{\dfrac{2\sin\alpha}{\cos\alpha}}{1-\dfrac{\sin^2\alpha}{\cos^2\alpha}}$$

$$\left.\begin{aligned}\therefore\ \tan 2\alpha&=\frac{2\tan\alpha}{1-\tan^2\alpha}\\\text{or}\quad\tan\theta&=\frac{2\tan\frac{\theta}{2}}{1-\tan^2\frac{\theta}{2}}\end{aligned}\right\}\ . \ . \ . \ . \ . \ . \ (xiii)$$

Also $\sin 3\alpha=\sin(2\alpha+\alpha)$
$=\sin 2\alpha\cos\alpha+\cos 2\alpha\sin\alpha$,
by applying formula (v).
$=2\sin\alpha\cos\alpha\cos\alpha+(\cos^2\alpha-\sin^2\alpha)\sin\alpha$,
by applying formulæ (xi) and (xii).
$=2\sin\alpha(1-\sin^2\alpha)+(1-2\sin^2\alpha)\sin\alpha$,
by applying formula (ii).

$\therefore\quad \sin 3\alpha=3\sin\alpha-4\sin^3\alpha$ . . . (xiv)

In a similar manner it may be proved that

$\cos 3\alpha=-3\cos\alpha+4\cos^3\alpha$ . . . (xv)

and $\tan 3\alpha=\frac{3\tan\alpha-\tan^3\alpha}{1-3\tan^2\alpha}$ . . . . (xvi)

Formulæ (i) to (iv) enable us to express any one trigonometrical ratio in terms of any other. For example, from (ii) we have

$$\sin\theta=\sqrt{1-\cos^2\theta},$$

an expression for the sine of an angle in terms of the cosine, and from (iv), calling $\tan\theta=x$, we have

$$1+\frac{1}{x^2}=\frac{1}{\sin^2\theta}$$

$$\therefore\quad\frac{x^2}{x^2+1}=\sin^2\theta,$$

and hence $\sin\theta=\frac{x}{\sqrt{1+x^2}}=\frac{\tan\theta}{\sqrt{1+\tan^2\theta}}$, an expression for the sine of an angle in terms of the tangent.

As an exercise, the student should make use of formulæ (ii), (iii), and (iv) to express the cosine of an angle in terms of the sine and of the tangent, and the tangent of an angle in terms of the sine and cosine. The results he should get are:

$$\cos\theta=\sqrt{1-\sin^2\theta}$$

$$\cos\theta=\frac{1}{\sqrt{1+\tan^2\theta}}$$

$$\tan\theta=\frac{\sin\theta}{\sqrt{1-\sin^2\theta}}$$

$$\tan\theta=\frac{\sqrt{1-\cos^2\theta}}{\cos\theta}$$

Having these, similar expressions for the cosecant, secant, and cotangent can be at once written down. For example, knowing that

$$\sin\theta = \frac{\tan\theta}{\sqrt{1+\tan^2\theta}}$$

we have $\quad \operatorname{cosec}\theta = \frac{\sqrt{1+\tan^2\theta}}{\tan\theta}$,

and so on for the secant and cotangent.

Trigonometrical Equations.—The relations expressed by formulæ (i) to (xvi) are extremely useful for the purpose of solving trigonometrical equations. The aim in *solving* such an equation is to find the value of an unknown angle. This is illustrated by the following examples:

Example 1.—Sin $\theta+\cos\theta=\sqrt{2}$. This is an equation involving the circular functions of an unknown angle θ. Its solution implies the determination of the value of θ. As the angle is expressed in terms of *two* of its functions, write sin θ in terms of cos θ (or *vice versa*). Doing so, we have $\sqrt{1-\cos^2\theta}+\cos\theta=\sqrt{2}$, an equation involving only *one* function of the angle. Writing x for cos θ, this becomes

$$\sqrt{1-x^2}+x=\sqrt{2}$$

$$\therefore\quad 1-x^2=2+x^2-2\sqrt{2x}$$

This simplifies to $x^2-\sqrt{2}x+\frac{1}{2}=0$, a quadratic in x, the solution of which is

$$x=\frac{1}{\sqrt{2}}=\pm\cdot707.$$

Hence $\quad \cos\theta=\pm\cdot707.$

Knowing the value of cos θ, we find from the tables that θ is an angle of $\pm45°$, or $\pm\frac{\pi}{4}$.

Example 2.—Solve, $\sec^2\theta+\tan\theta=1$.

$$\therefore\quad 1+\tan^2\theta+\tan\theta=1$$
$$\therefore\quad \tan^2\theta+\tan\theta=0$$
$$\therefore\quad \tan\theta=0, \text{ or } \tan\theta=-1$$
$$\therefore\quad \theta=0, \text{ or } \theta=-45° \text{ or } -\frac{\pi}{4}$$

(There are also positive angles—greater than 90°—whose tangent may be -1. The *general* solution is given on p. 537.)

Example 3.—Solve, $\sin 3\theta=2\sin\theta$.

$\therefore\quad 3\sin\theta-4\sin^3\theta=2\sin\theta$ . . . by (xiv)

Dividing by sin θ:

$$3-4\sin^2\theta=2$$
$$\sin^2\theta=\frac{1}{4}$$

$\therefore\quad \sin\theta=\pm\frac{1}{2}$, and also $\sin\theta=0$, since we have divided by sin θ.

$\therefore\ \theta=0$; $\theta=30°$, *i.e.* $\frac{\pi}{6}$; $\theta=-30°$, *i.e.* $-\frac{\pi}{6}$.

These are not the only solutions. The general solution will be clear after reading to p. 536.

Ratios of Angles of Any Size.—Hitherto only angles smaller than a right angle have been considered. We must now investigate the trigonometrical ratios of angles of *any* size. Let AB be the fixed line, and let the circle, described by the rotating line AC during a complete revolu-

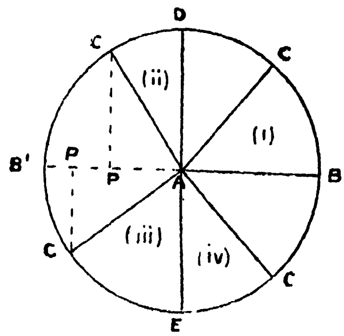


FIG. 8.

tion, be divided into four equal quadrants by the lines BAB′ and DAE. It is evident that AC falls within the first, second, third, or fourth quadrant, according as the angle described by it is less than one, two, three, or four right angles. We need not necessarily stop at four right angles; an angle of 400°, for example, implies a complete circular revolution of AC, together with an additional revolution through another 40°. The sine, cosine, and tangent of an angle of 400° would, however, be exactly the same as for an angle of 40°. It is also evident from the figure that, in the case of angles between 90° and 270°$\left(\frac{\pi}{2}\text{ and }\frac{3\pi}{2}\right)$, the perpendicular from C no longer falls on AB, but on BA *produced*, so that for such angles the intercept AP is no longer a line situated between A and B.

Hence, in considering the trigonometrical ratios of angles greater than 90° or $\frac{\pi}{2}$, we must take into account the *directions* in which distances are measured. The established convention is to call horizontal distances *positive* when measured to the *right* of DE, and *negative* when measured to the *left* of DE. Similarly, vertical distances are *positive* when *above* the line B′B, and *negative* when *below*. The line AC itself is always positive, since it is always measured in the *same* direction, viz. from the centre of the circle to the circumference. Consequently, for angles between 0° and 90° (AC situated in the first quadrant), *all* the distances concerned in the trigonometrical ratios—hypotenuse, perpendicular, and intercept—are positive, and the ratios themselves are all positive quantities.

For angles between 90° and 180° (AC situated in the second quadrant), both the hypotenuse and perpendicular are positive, but the intercept

is negative; consequently the sine of any such angle is positive, but the cosine and tangent are negative quantities. Similarly, for angles between 180° and 270° the sine and cosine are both negative quantities, but the tangent, being the result of division of two negative quantities, is positive. For angles between 270° and 360°, the sine and tangent are negative quantities, while the cosine is positive. It is no use trying to remember these facts by heart—the consideration of a rough figure, quickly drawn, will immediately supply these data. The preceding formulæ (i) to (xvi) hold for angles of any size, provided due regard is paid to signs.

For an angle θ, greater than a right angle but

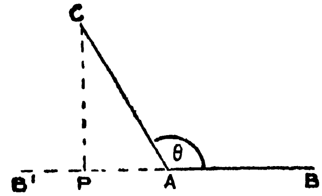


FIG. 9.

less than two right angles, we have (Fig. 9), $=+\frac{PC}{AC}$. But $\frac{PC}{AC}$=sine of the angle B′AC—*i.e.*

$$\sin(180°-\theta),$$

or, in circular measure, $\sin(\pi-\theta)$.

Hence $\sin\theta=\sin(\pi-\theta)$ . . . . . (xvii)

The angles θ and $(\pi-\theta)$ are each called the *supplement* of the other.

Also $\cos\theta=-\frac{AP}{AC}$, since AP is a negative quantity. (See Fig. 9.)

But $+\frac{AP}{AC}$=cos of the angle B′AC, *i.e.* $\cos(\pi-\theta)$.

Hence $\cos\theta=-\cos(\pi-\theta)$ . . . . (xviii)
Similarly, $\tan\theta=-\tan(\pi-\theta)$ . . . (xix)

These equations are very important, and should be committed to memory. Equations somewhat similar to these hold good for angles in

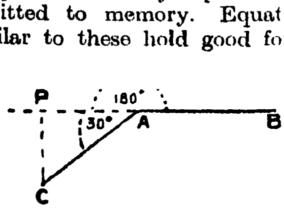


FIG. 10.

the third and fourth quadrants. For example, from the adjoining figure we see that

$$\sin 210°=\sin(180°+30°)=-\frac{PC}{AC}=-\sin 30°,$$

since PC is negative. In the same manner the values of the circular functions of all angles greater than a right angle can be found in terms of the same function of an angle less than a right angle.

It is now apparent that, knowing the values of the sine, cosine, and tangent of all angles between 0° and 90° $\left(\text{or } 0 \text{ and } \frac{\pi}{2}\right)$, we know the values of these functions for *any* angle. In fact, as regards the sine and cosine, we only require these values for angles up to 45°, since $\sin\theta=\cos(90°-\theta)$. (See p. 532.) In a book of mathematical tables, therefore, the values of the sine and cosine are only given for angles from 0° to 45°, while the values of the tangent are given from 0° to 90°. Such a table giving values to 5 decimal places will be found at the end, p. 541.

The Sine Curve.—Considering the variations in the values of the circular functions of angles, we find the following.

The value of the sine of an angle varies from 0 to 1 for angles between 0° and 90° $\left(0 \text{ and } \frac{\pi}{2}\right)$; from 1 to 0, again, for angles between 90° and 180° $\left(\frac{\pi}{2} \text{ and } \pi\right)$; from 0 to -1 for angles between 180° and 270° $\left(\pi \text{ and } \frac{3\pi}{2}\right)$; and from -1 to 0 for angles between 270° and 360° $\left(\frac{3\pi}{2} \text{ and } 2\pi\right)$. These values are then repeated exactly for angles greater than 2π—*e.g.* from 0 to 1 for angles between 360° and 450° $\left(2\pi \text{ and } \frac{5\pi}{2}\right)$, &c.

These variations can be represented graphically. Let the horizontal direction represent the numerical value of the angle, and the vertical direction the value of its sine. The above variations for the sine of any angle between 0° and 360° will then be represented by the following curve, called the *sine curve* (Fig. 11).

The portion of the curve OA can be drawn accurately by the help of the tables. The portion AB balances exactly about the line AA′, while the rest of the curve BCD is exactly similar to the portion OAB. The curve evidently does not stop at D, but repeats itself exactly and *ad infinitum* beyond D, and also to the left or negative side of OY. (The continuation of the curve is shown by a dotted line in the figure.) The curve is therefore *periodic*, repeating itself after a certain period. With the usual convention, in which any horizontal distance is designated by the letter x and any vertical distance by y, the equation of this curve becomes $y=\sin x$, or since x represents the numerical value of the angle θ, $y=\sin\theta$.

Turning now to Example 3 (p. 534), the solution of the equation $\sin 3\theta=2\sin\theta$ was found to be $\sin\theta=0$, $\sin\theta=\frac{1}{2}$, and $\sin\theta=-\frac{1}{2}$. Now *all* the angles whose sine is zero are given by the points of intersection of the sine curve with the axis XOX′; hence these angles are

0, π, 2π, 3π, &c.; $-\pi$, -2π, -3π, &c. All these are summed up in the statement that $\theta = n\pi$, where n is any positive or negative integer.

Similarly, the solution $\sin \theta = \pm \frac{1}{2}$ is given by *all* the points of intersection of the curve with the lines $y = \pm \frac{1}{2}$, *i.e.* the lines PQR and STU. These points are: $a = \frac{\pi}{6}$, $b = \left(\pi - \frac{\pi}{6}\right)$, $c = \left(\pi + \frac{\pi}{6}\right)$, $d = \left(2\pi - \frac{\pi}{6}\right)$, &c.; and on the negative side of OY, $a' = -\frac{\pi}{6}$, $b' = -\left(\pi - \frac{\pi}{6}\right)$,

$$c' = -\left(\pi + \frac{\pi}{6}\right).$$

$$d' = -\left(2\pi - \frac{\pi}{6}\right), \text{ \&c.}$$

All these are summed up by stating that $\theta = n\pi \pm \frac{\pi}{6}$, where n is any positive or negative integer. Hence the *complete* solution of the equation, $\sin 3\theta = 2 \sin \theta$, is $\theta = n\pi$ and $\theta = n\pi \pm \frac{\pi}{6}$, n being any positive or negative integer, zero included.

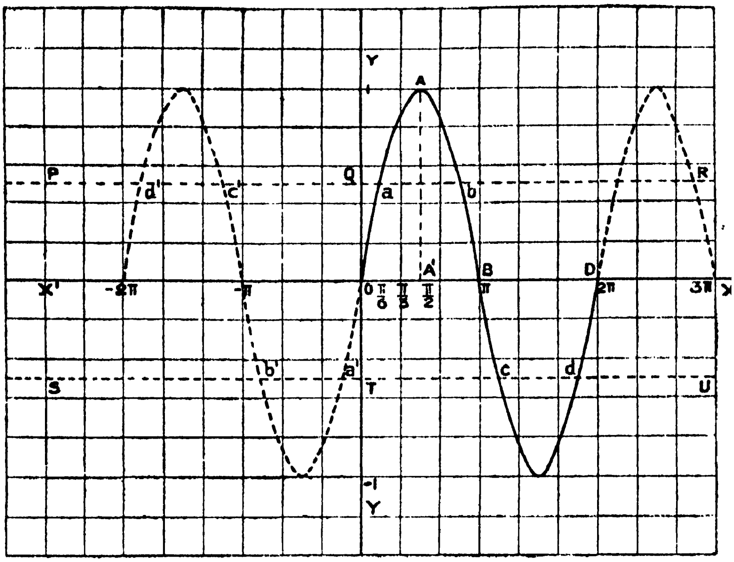


FIG. 11.

The Cosine Curve.—A similar curve to the above can be drawn for the cosine of any angle, and since $\cos 0° = 1$ and $\cos 90° = 0$, the curve, called the *cosine curve*, is of the form shown in Fig. 12 and its equation is $y = \cos x$, or $y = \cos \theta$.

In Example 1 (p. 534) the solution of the equation $\sin \theta + \cos \theta = \sqrt{2}$ was found to be $\cos \theta = \pm \cdot 707$. Considering this in connection with the cosine curve, we see at once that $\theta = \pm 45°$, or $\pm \frac{\pi}{4}$, are not the only angles whose cosine is $\pm \cdot 707$. For the lines QR and ST, distant $\pm \cdot 707$ from XOX′, cut the curve at an infinite number of points—a, b, a', b', c, d, c', d', &c., and these points correspond to angles $\frac{\pi}{4}$, $\left(\frac{3\pi}{2} + \frac{\pi}{4}\right)$, $-\frac{\pi}{4}$, $-\left(\frac{3\pi}{2} + \frac{\pi}{4}\right)$, $\left(\frac{\pi}{2} + \frac{\pi}{4}\right)$, $\left(\pi + \frac{\pi}{4}\right)$, $-\left(\frac{\pi}{2} + \frac{\pi}{4}\right)$, $-\left(\pi + \frac{\pi}{4}\right)$, &c. The complete solution is therefore $\theta = \pm\left(\frac{n\pi}{2} + \frac{\pi}{4}\right)$, n being any positive or negative integer.

It will be noticed that the above two curves are exactly similar in shape. If, in the case of

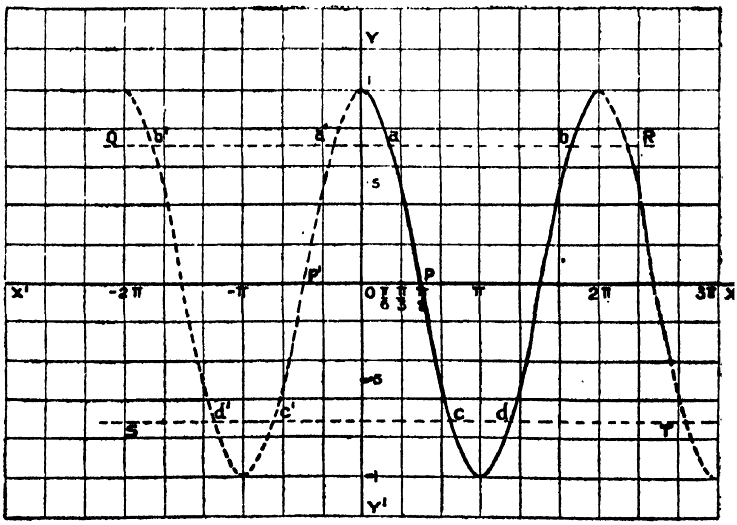


FIG. 12.

the sine curve, we move the origin to A′ it becomes the cosine curve; and in the case of the cosine curve, a change of origin from O to P′ will give us the sine curve. Both these curves are important in the consideration of periodic motions, termed *simple harmonic* motions, such as the swinging of a simple pen-

dulum, or the wave-motions producing sound, light, or radiant heat.

The Tangent Curve.—The following curve (Fig. 13) is the graphical representation of the

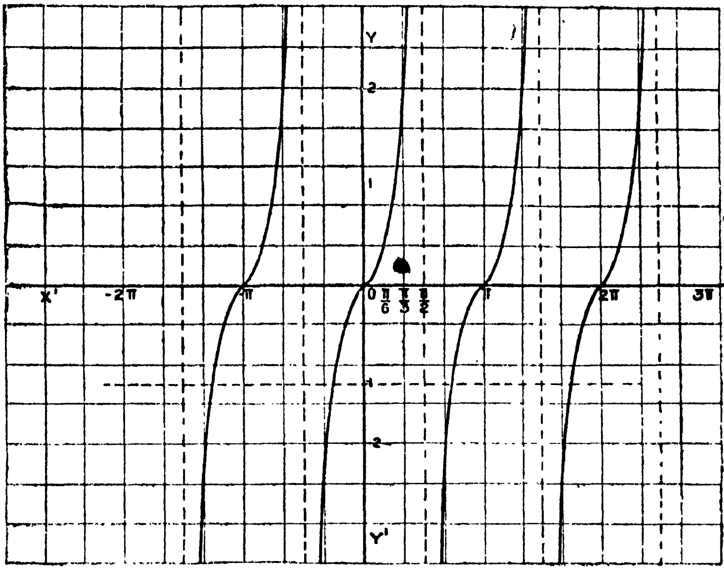


FIG. 13.

tangent of any angle, and is constructed in the same manner as the preceding sine and cosine curves.

The equation of this curve is $y=\tan x$ or $y=\tan\theta$.

Considering the solution of Example 2 (p. 534), viz. $\tan\theta=0$, or $\tan\theta=-1$, the curve shows that $\tan\theta=0$ is given by the angles 0, π, 2π, &c., $-\pi$, -2π, &c., *i.e.* by $\pm n\pi$; while $\tan\theta=-1$ is given by the angles $-\frac{\pi}{4}$, $\left(\pi-\frac{\pi}{4}\right)$, $\left(2\pi-\frac{\pi}{4}\right)$, &c., $-\left(\pi-\frac{\pi}{4}\right)$, $-\left(2\pi-\frac{\pi}{4}\right)$, &c., *i.e.* by $\pm\left(n\pi-\frac{\pi}{4}\right)$, n, as before, being any integer.

Solution of Triangles.—Angles of elevation or depression, as well as angles in a horizontal plane, can be easily and accurately measured by means of a theodolite. By also measuring a *convenient* line or distance we can now calculate exactly certain other distances whose actual measurement would be difficult or impossible. In the case of a right-angled triangle such a calculation is quite simple.

For example, a flagstaff 20 ft. high stands on top of a cliff. From a point in a line with the foot of the cliff the angles of elevation of the highest and lowest points of the flagstaff are observed to be 38° 47′ and 40° 10′ respectively. Required to find the height of the cliff.

Let BC represent the cliff, CD the flagstaff, and A the point from which the angles are measured (Fig. 14). Join AB, AC, and AD. Then CD is 20 ft. the angle BAC is 38° 47′, and the angle BAD is 40° 10′. Let $BC=x$, $AB=y$.

From the mathematical tables we find then

$$\tan 38^\circ 47' = \cdot 8035418$$

and

$$\tan 40^\circ 10' = \cdot 8440688$$

Hence

$$\frac{x+20}{y}=\cdot 8440688$$

and

$$\frac{x}{y}=\cdot 8035418.$$

Solve for x. By division we get

$$\frac{x+20}{x}=\frac{\cdot 8440688}{\cdot 8035418}$$

$$1+\frac{20}{x}=1+\frac{\cdot 0405270}{\cdot 8035418}$$

$$\frac{20}{x}=\cdot 0504$$

and $x=\frac{20}{\cdot 0504}=396\cdot 8$ ft., which is the height of the cliff.

By substituting this value of x in the equation $\frac{x}{y}=\cdot 8035418$, we can also determine the value of y if required. And since $AC^2=x^2+y^2$, and

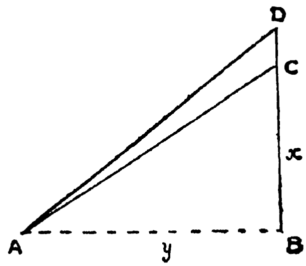


FIG. 14.

$AD^2=(x+20)^2+y^2$, the distances AC and AD can also be calculated.

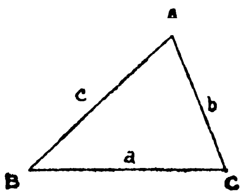


FIG. 15 (i)

To solve triangles other than right-angled, we must first see what relations exist between the sides and angles of *any* triangle.

There are three possible kinds of triangles: (1) All the angles of the triangle are acute (Fig. 15, i); (2) one angle is obtuse, *i.e.* greater than a right angle, and the remaining two

angles acute (Fig. 15, ii): (3) one angle is a right angle (Fig. 15, iii).

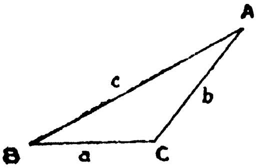


Fig. 15 (ii)

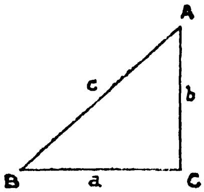


Fig. 15 (iii)

Let a, b, c represent the lengths of the sides, and A, B, C the angles opposite these sides respectively.

From Euclid, Bk. I, Prop. 32, we know that

$$A+B+C=180°, \text{ or } \pi \quad . \quad . \quad . \quad . \quad . \quad (\mathbf{xx})$$

By drawing a perpendicular from A to BC it can be easily proved that in all three cases

$$\left.\begin{aligned} a &= b\cos C + c\cos B \\ b &= c\cos A + a\cos C \\ c &= a\cos B + b\cos A \end{aligned}\right\} \quad . \quad . \quad . \quad . \quad . \quad (\text{xxi})$$

Also, that the sides are proportional to the sines of the angles, *i.e.*

$$\frac{a}{\sin A}=\frac{b}{\sin B}=\frac{c}{\sin C} \quad . \quad . \quad . \quad . \quad . \quad (\text{xxii})$$

Also, that

$$\left.\begin{aligned} \cos A &= \frac{b^2+c^2-a^2}{2bc} \\ \cos B &= \frac{c^2+a^2-b^2}{2ac} \\ \cos C &= \frac{a^2+b^2-c^2}{2ab} \end{aligned}\right\} \quad . \quad . \quad . \quad . \quad . \quad . \quad (\text{xxiii})$$

If we call half the sum of the sides s, so that

$$\frac{a+b+c}{2}=s,$$

then with the aid of equation (xxiii) it may be proved that

$$\left.\begin{aligned} \sin\frac{A}{2} &= \sqrt{\frac{(s-b)(s-c)}{bc}} \;* \\ \cos\frac{A}{2} &= \sqrt{\frac{s(s-a)}{bc}} \end{aligned}\right. \quad . \quad . \quad (\text{xxiv})$$

And by division it follows that

$$\tan\frac{A}{2}=\sqrt{\frac{(s-b)(s-c)}{s(s-a)}}$$

* Since $\cos A = 1 - 2\sin^2\frac{A}{2}$ (equation xii, on p. 533).

$$\therefore \quad 2\sin^2\frac{A}{2} = 1-\cos A$$
$$= 1 - \frac{b^2+c^2-a^2}{2bc} \text{ (equation xxiii above).}$$
$$\therefore \quad \sin^2\frac{A}{2} = \frac{2bc-b^2-c^2+a^2}{2\cdot 2bc} = \frac{a^2-(b-c)^2}{2\cdot 2bc}$$
$$= \frac{(a+b-c)(a-b+c)}{2\cdot 2\cdot bc}$$
$$= \left(\frac{a+b+c-2c}{2}\right)\left(\frac{a+b+c-2b}{2}\right)\cdot\frac{1}{bc}$$
$$= \frac{(s-c)(s-b)}{bc}$$
$$\sin\frac{A}{2} = \sqrt{\frac{(s-b)(s-c)}{bc}}$$

The proof for $\cos\frac{A}{2}=\sqrt{\frac{s(s-a)}{bc}}$ is similar to this.

Similar expressions hold for $\sin\frac{B}{2}$, $\cos\frac{B}{2}$, $\tan\frac{B}{2}$, and for $\sin\frac{C}{2}$, $\cos\frac{C}{2}$, $\tan\frac{C}{2}$. Thus

$$\sin\frac{B}{2}=\sqrt{\frac{(s-a)(s-c)}{ac}}, \text{ \&c.}$$

Since $\sin A = 2\sin\frac{A}{2}\cos\frac{A}{2}$, an application of equation (xxiv) gives

$\sin A = \frac{2}{bc}\sqrt{s(s-a)(s-b)(s-c)}$, and if the quantity $\sqrt{s(s-a)(s-b)(s-c)}$ be denoted by S, then

$$\left.\begin{aligned} & \sin A = \frac{2S}{bc} \\ \text{and, similarly,} \quad & \sin B = \frac{2S}{ac} \\ \text{and} \quad & \sin C = \frac{2S}{ab} \end{aligned}\right\} \quad . \quad . \quad . \quad (\mathbf{xxv})$$

From equation (**xx**ii) the following formula is deducible:

$$\left.\begin{aligned} & \tan\frac{A-B}{2} = \frac{a-b}{a+b}\cot\frac{C}{2} \\ \text{and, similarly,} \quad & \tan\frac{B-C}{2} = \frac{b-c}{b+c}\cot\frac{A}{2} \\ \text{and} \quad & \tan\frac{A-C}{2} = \frac{a-c}{a+c}\cot\frac{B}{2} \end{aligned}\right\} \quad . \quad . \quad (\text{xxvi})$$

For proofs of the equations (xxi to **xxvi**) the reader should refer to a text-book. In practice it is their application that is the most important point.

A careful scrutiny of the formulæ or equations **xxii** to xxvi will show that each is an equation involving four elements of a triangle. Hence, knowing any three elements, we apply an equation containing the three given elements, and from it find the fourth. By a similar procedure the fifth and sixth elements of the triangle are found. But, it should be noted, at least three elements must be known before an attempt can be made to find the others.

Now, of the three sides and three angles constituting a triangle we might know:

(1) The three angles.
(2) The three sides.
(3) One side and two angles.
(4) Two sides and the angle between them.
(5) Two sides and the angle opposite one of them.

This exhausts all the possibilities. We will consider them in turn.

(1) *Given the Three Angles.*—This case cannot be solved, since it is possible to construct an infinite number of triangles, all of which will have the three angles equal to each other. This

is apparent from the accompanying figure. The sides of the triangles being drawn parallel to each

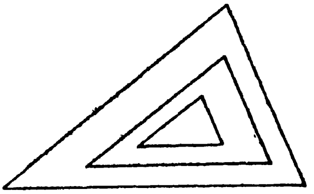


FIG. 16.

other, the angles of any one are exactly equal to those of any other, although the sides are not.

(2) *Given the Three Sides.*—In this case we apply a formula in which the three sides and one angle are involved. Evidently any one of the equations (xxiii), (xxiv), or (xxv) is applicable. As a simple example, suppose the given sides are $a=3$ ft., $b=4$ ft., $c=5$ ft. Applying (xxiii):

$$\cos A = \frac{b^2+c^2-a^2}{2bc} = \frac{16+25-9}{2\cdot4\cdot5} = \frac{32}{40} = \cdot8$$

From the tables we obtain $A = 36°\ 52'\ 11''$, which is the angle opposite the side of length 3 ft.

$$\text{Also } \cos C = \frac{a^2+b^2-c^2}{2ab} = \frac{9+16-25}{2\cdot3\cdot4} = 0$$

$\therefore\ C = 90°$, which is the angle opposite the side of length 5 ft., and $B = (180° - A - C) = 53°\ 7'\ 49''$, which is the angle opposite the side of length 4 ft.

Had (xxiv) been applied, the calculation would have been:

$$\sin\frac{A}{2} = \sqrt{\frac{(s-b)(s-c)}{bc}}$$

Now $\quad 3+4+5$

$$\sin\frac{A}{2} = \sqrt{\frac{2\times1}{20}} = \sqrt{\cdot1} = \cdot316228 \text{ (by using logarithms)}$$

From the tables $\frac{A}{2} = 18°\ 26'\ 5\cdot5''$, and therefore $A = 36°\ 52'\ 11''$, as before.

Similarly, we can find B, and hence C.

Equation (xxv) can be applied in the same manner, and will, of course, give the same results.

Of the three formulæ applicable, (xxiii) is the simplest for this particular example; but, when larger figures are involved, either (xxiv) or (xxv) should be used, as they are in factorial form, and the calculation can therefore be made with the aid of a table of logarithms, whereas logarithms cannot be applied to (xxiii).

Since any two sides of a triangle are together greater than the third (Euclid, Bk. I, Prop. 20), it follows that unless the given data comply with this condition the triangle cannot be constructed.

(3) *Given One Side and Two Angles.*—The third angle can be at once found by subtracting the sum of the given two angles from 180°. Evidently the only formula applicable to the given data is (xxii). Suppose the given side is a. Then, since $\frac{a}{\sin A} = \frac{b}{\sin B}$, we have $b = \frac{a \sin B}{\sin A}$, and as all the quantities on the right-hand side of this equation are given, b can be immediately calculated. Similarly, c is found from $= \frac{a \sin C}{\sin A}$.

(4) *Given Two Sides and the Angle between them.*—We will suppose the given quantities are a, b, and C. Glancing through the preceding formulæ, we see that formula (xxiii), viz.

$$\cos C = \frac{a^2+b^2-c^2}{2ab},$$

contains the given quantities a, b, and C, together with but one other, c. Hence it is applicable to this particular case. Putting this equation into another form we have $c^2 = a^2 + b^2 - 2ab \cos C$, which gives us the value of c^2, and hence of c. Knowing c, we next apply the equation $\cos B = \frac{c^2+a^2-b^2}{2ac}$ and find B. A is now given by $A = (180° - B - C)$. As formula (xxiii) cannot be used with a table of logarithms, it is only suitable when small figures are involved. We therefore seek for another formula, and find it in (xxvi), viz.

$$\tan\frac{A-B}{2} = \frac{a-b}{a+b}\cot\frac{C}{2}.$$

All the quantities on the right-hand side of this equation are known, and hence we can calculate the value of $\tan\frac{A-B}{2}$; from the tables we find what $\frac{A-B}{2}$ is, and therefore the value of $(A-B)$. We also know the value of $(A+B)$, since $(A+B) = 180° - C$. Hence we can find both A and B. Knowing now the values of A, B, C, a and b, we at once find c from equation (xxii).

Let us take a concrete example. Suppose $a = 435$ chains, $b = 257$ chains, and $C = 40°$. Applying equation (xxvi) we have

$$\tan\frac{A-B}{2} = \frac{178}{692}\cot 20°.$$

Taking logarithms:

$$\text{Logarithmic } \tan\frac{A-B}{2}$$

$= \log. 178 - \log. 692 + \text{logarithmic } \cot 20°$

$= 2\cdot2504200 - 2\cdot8401061 + 10\cdot4389341$ (from the tables)

$= 9\cdot8492480.$

The tables give $\frac{A-B}{2}=35° \, 14' \, 58''$,

$$\therefore \quad A-B=70° \, 29' \, 56''.$$

Now $\qquad A+B=(180°-C)=140°.$

Adding the last two equations:

$$2A=210° \, 29' \, 56''$$

$$\therefore \quad A=105° \, 14' \, 58''$$

and $\quad \therefore \quad B=34° \, 45' \, 2''$

Now $c=\frac{a \sin C}{\sin A}$, which reduces (with the aid of the tables) to $c=289{\cdot}818$.

Hence all the elements of the triangle are now known.

(5) *Given Two Sides and the Angle opposite one of them.*—Let us suppose that the given quantities are a, b, and B. Then from equation (xxii) we get, $\sin A=\frac{a \sin B}{b}$, from which the value of A can be found. Knowing A and B, C is then known; and applying formula (xxii) again we get, $c=\frac{a \sin C}{\sin A}=\frac{b \sin C}{\sin B}$, from which c can be found. All the elements are then known.

The given data, viz., two sides and the angle opposite one of them, frequently admit of two solutions, sometimes of one, and sometimes of none at all. This will be clear from a consideration of the adjoining figure. The unknown side c is fixed in *position* by the

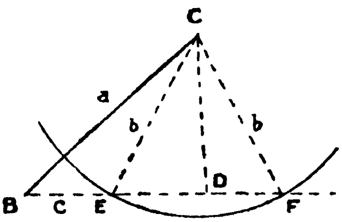


FIG. 17.

given angle B between a and c. The side b is fixed in length but not in position. Now if b is smaller than a, but larger than the perpendicular CD—*i.e.* larger than a sin B—then *two* lines each of length b can be drawn to complete the triangle, for with centre C and radius b, a circle can be drawn to cut BD in two points, viz. at E and F, and both CE and CF are each equal to b. In other words, the *two* triangles, CBE and CBF, both comply with the given conditions. But if b is equal to a or larger than a, then only one solution is possible,* whereas if b is less than a sin B, *i.e.* less than CD, then a circle drawn with such a radius will not cut the line BD, and the triangle cannot be constructed at all.

These theoretical considerations will become clear from the following simple examples:

Example 1.—Given $a=30$, $b=25$, $B=50°$.

$$\sin A=\frac{a \sin B}{b}=\frac{30 \sin 50°}{25},$$

and as $\sin 50°=\cos 40°={\cdot}7660444$ (from the tables),

$$\sin A=\frac{6}{5}\times{\cdot}7660444={\cdot}9192533$$

$$A=66° \, 49' \, 2''.$$

But as $\sin A=\sin(180°-A)$, it follows that A might also have the value $113° \, 10' \, 58''$.

If $A=66° \, 49' \, 2''$, then $(A+B)=116° \, 49' \, 2''$, and therefore $C=63° \, 10' \, 58''$.

If $A=113° \, 10' \, 58''$, then $(A+B)=163° \, 10' \, 58''$, and therefore $C=16° \, 49' \, 2''$.

Now $\qquad c=\frac{a \sin C}{\sin A}$

$$=30\times\frac{\sin 63° \, 10' \, 58''}{{\cdot}9192533}$$

$$=30\times\frac{\sin 16° \, 49' \, 2''}{{\cdot}9192533}$$

which reduces to $c=29{\cdot}12$, or $c=9{\cdot}44$.

Hence there are two solutions, viz.:

(1) $A=66° \, 49' \, 2''$; $C=63° \, 10' \, 58''$; $c=29{\cdot}12$.

(2) $A=113° \, 10' \, 58''$; $C=16° \, 49' \, 2''$; $c=9{\cdot}44$.

Example 2.—Given $a=30$, $b=40$, $B=50°$.

$$\sin A=\frac{30}{40}\sin 50°=\frac{3}{4}\times{\cdot}7660444={\cdot}574533$$

$$\therefore \quad A=35° \, 4' \, 1'',$$

* *b larger than a.*—A circle, drawn with centre C and radius b, will still cut BD in two points, E and F, but only

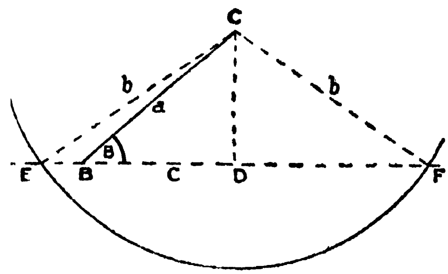


FIG. 18.

the triangle BCF is admissible, since in the triangle BCE the angle opposite CE=(180°−B), whereas the given condition is that the angle must be B.

or, as in Example 1, A might have the value 144° 55′ 59″. But in the latter event (A+B) would equal 194° 55′ 59″. And as any two angles of a triangle must be, together, less than two right angles, the second value for A is inadmissible, and A can only have the value 35° 4′ 1″. With the given data, therefore, there is only one solution.

C and c can now be found as in Example 1.

Example 3.—Given $a=30$, $b=20$, $B=50°$.

$$\therefore \quad \sin A = \frac{3}{2} \times \cdot 7660444 = 1 \cdot 1490666$$

But since the sine of any angle cannot be greater than unity, A is an impossible angle. In other words, it is impossible to construct a triangle with these data.

TRIGONOMETRICAL RATIOS

$$\text{Hypotenuse} = \sqrt{(\text{Intercept})^2 + (\text{Perp.})^2}$$

$$\text{Sin A} = \frac{\text{Perp.}}{\text{Hypot.}}$$

$$\text{Cos A} = \frac{\text{Intercept}}{\text{Hypot.}}$$

$$\text{Tan A} = \frac{\text{Perp.}}{\text{Intercept}} = \frac{\text{Sin A}}{\text{Cos A}}$$

Angle.	Sin.	Cos.	Tan.	Angle.	Sin.	Cos.	Tan.	Angle.	Tan.
0°	·0	1·0	·0						
1°	·01745	·99985	·01746	31°	·51504	·85717	·60086	61°	1·80405
2°	·03490	·99939	·03492	32°	·52992	·84805	·62487	62°	1·88073
3°	·05234	·99863	·05241	33°	·54464	·83867	·64941	63°	1·96261
4°	·06976	·99756	·06993	34°	·55919	·82904	·67451	64°	2·05030
5°	·08716	·99619	·08749	35°	·57358	·81915	·70021	65°	2·14451
6°	·10453	·99452	·10510	36°	·58779	·80902	·72654	66°	2·24604
7°	·12187	·99255	·12278	37°	·60181	·79864	·75355	67°	2·35585
8°	·13917	·99027	·14054	38°	·61566	·78801	·78129	68°	2·47509
9°	·15643	·98769	·15838	39°	·62932	·77715	·80978	69°	2·60509
10°	·17365	·98481	·17633	40°	·64279	·76604	·83910	70°	2·74748
11°	·19081	·98163	·19438	41°	·65606	·75471	·86929	71°	2·90421
12°	·20791	·97815	·21256	42°	·66913	·74314	·90040	72°	3·07768
13°	·22495	·97437	·23087	43°	·68200	·73135	·93252	73°	3·27085
14°	·24192	·97030	·24933	44°	·69466	·71934	·96569	74°	3·48741
15°	·25882	·96593	·26795	45°	·70711	·70711	1·0	75°	3·73205
16°	·27564	·96126	·28675	46°			1·03553	76°	4·01078
17°	·29237	·95630	·30573	47°			1·07237	77	4·33148
18°	·30902	·95106	·32492	48°			1·11061	78°	4·70463
19°	·32557	·94552	·34433	49°			1·15037	79°	5·14455
20°	·34202	·93969	·36397	50°			1·19175	80°	5·67128
21°	·35837	·93358	·38386	51°			1·23490	81°	6·31375
22°	·37461	·92718	·40403	52°			1·27994	82°	7·11537
23°	·39073	·92050	·42447	53°			1·32704	83°	8·14435
24°	·40674	·91355	·44523	54°			1·37638	84°	9·51436
25°	·42262	·90631	·46631	55°			1·42815	85°	11·43005
26°	·43837	·89879	·48773	56°			1·48256	86°	14·30067
27°	·45399	·89101	·50953	57°			1·53986	87°	19·08114
28°	·46947	·88295	·53171	58°			1·60033	88°	28·63625
29°	48481	·87462	·55431	59°			1·66428	89°	57·28996
30°	5	·86603	·57735	60°			1·73205	90°	Infinite.

Since Sin A = Cos (90°—A) and Cos A = Sin (90°—A) the Sines and Cosines of angles from 46° to 90° can be found from above.
For example :—
Sin 53° = Cos (90°—53°) = Cos 37° = ·79864
Cos 64° = Sin (90°—64°) = Sin 26° = ·43837

For angles between 90° and 180° :—
Sin A = Sin (180°—A).
Cos A = —Cos (180°—A).
Tan A = —Tan (180°—A).
They can therefore be found from this table.
Examples :—Sin 100° = Sin (180°—100°) = Sin 80° = Cos 10° = ·98481.
Cos 100° = —Cos (180°—100°) = —Cos 80° = —Sin 10° = —·17365.
Tan 100° = —Tan (180°—100°) = —Tan 80° = —5·67128.

COURSE OF READING

The student of trigonometry will find it essential, first to acquire a good working knowledge of elementary algebra. (See Arithmetic and Algebra.) Some knowledge of Euclid (the first six books), or at least those propositions dealing with triangles and circles, is also necessary. (See Geometry.)

There are many text-books on trigonometry, but there is little to choose between them. To mention three: *Plane Trigonometry*, by Loney, Part I (Cambridge University Press); *An Elementary Treatise on Plane Trigonometry*, by Hodson and Jessop (Cambridge University Press); *Elementary Trigonometry*, by J. B. Lock (Macmillan & Co.).

In reading a subject like trigonometry it is not advisable to use more than one text-book. Having chosen one's text-book, it should be read very slowly, carefully, and methodically. Above all, *a large number of examples should be worked.* To read any book on mathematics without working examples is but of very little use.

Text-books on trigonometry usually contain a chapter on "logarithms," and another on "the use of mathematical tables." The student is strongly advised to make himself or herself

thoroughly familiar with the contents of these chapters.

The rest of the text-book will be found summarised in this article—a summary which it is hoped will enable the student to grasp quickly the principles and applications of the subject, and thus form a preparation for further serious study.

The student who wishes to go more deeply into the subject should read *Plane Trigonometry*, Part II, by Loney. To do so, however, more than an elementary knowledge of algebra is necessary.

For spherical trigonometry, necessary for survey work on a large scale and for astronomy, read *Spherical Trigonometry*, by Todhunter and Leathem (Macmillan & Co.).

A book of mathematical tables is published by Chambers & Co.

M. ZAKTRAGER, B.Sc. (Lond.)

COURSE OF READING

PURE Mathematics may either be regarded as a desirable subject for study for its own sake, affording as it does an admirable training in the development of ordered reasoning, or as a means to an end, for there are few subjects to-day which do not admit in some way of the application of mathematical processes, so that a comprehensive mathematical knowledge has become an absolute essential to the scientific student.

Assuming a knowledge of the elementary processes and results of arithmetic, which may be obtained from any good text-book, these ideas should be first extended by a study of *elementary algebra*, using some text-book such as Baker and Bourne's *Elementary Algebra* (G. Bell & Sons) or Hall & Knight's (Macmillan & Co.), and working a large number of examples. This latter is essential, and should be taken as applying to all subsequent work, as no sound knowledge of the subject can be secured without it. Neatness and order of arrangement should also be attended to from the first, as it will be found of the greatest help in both the elementary and advanced work, particularly the latter. Graphical algebra should be dealt with in conjunction with the corresponding theoretical work, and will form a basis for co-ordinate geometry, serving also as an introduction to the idea of variation of a function, developed further in the Calculus. *Euclidean Geometry* should be studied at the same time, care being taken to assimilate the methods of proof of the various propositions. Deductions should be written out in full, so that the student will acquire the power of applying and at the same time testing the knowledge he has obtained. A good text-book is Hall and Steven's *School Geometry* (Macmillan & Co.). A start should also be made with *Trigonometry*, and it would be advisable to work from one of the larger text-books, selecting first the more elementary portions and working as far as the solution of triangles. Text-book suggested: *Trigonometry*, Parts I and II, by Loney. See section on *Trigonometry*.

After a thorough grounding in such elementary work, the student will be ready for a more extensive and advanced study. The development of the subject will, of course, be gradual, and the student will necessarily be guided to some extent by the end he has in view. Hence it is difficult to give a scheme suitable for all, but a student having in view (say) an honours degree in mathematics should proceed on the lines indicated below.

A brief summary will first be given showing roughly the order in which the various branches of the subject should be taken, and then each branch will be dealt with separately, and suggestions given for following them up as far as may be desired.

I. (*a*) More advanced Alegebra and Trigonometry.

(*b*) Modern Plane Geometry.

(*c*) Analytical and Pure Geometry (two dimensions).

(*d*) Elementary Calculus.

Many students postpone a study of the Calculus till comparatively late. This is a great mistake, as the elementary principles are easy to grasp, and the subject is so wide in its application that even an elementary knowledge is of considerable use.

II. Higher developments of all subjects.

(*a*) Algebra, including determinants, theory of equations, algebraic series, especially convergence of series, &c.

(*b*) Trigonometry, including complex quantities, trigonometrical series, and properties of exponential and hyperbolic functions.

(*c*) Geometry, including projection and reciprocation, geometry of higher plane curves, and solid geometry, also elementary invariants and co-variants.

(*d*) Calculus, more advanced, with simple differential equations.

III. Special branches of above subjects.

(*a*) Theory of numbers; advanced theory of equations, with application of determinants, invariants and co-variants.

(*b*) Theory of functions of a real variable, and of a complex variable.
(*c*) Differential equations treated more fully, including partial differential equations.
(*d*) Fourier's Series, Gamma and allied functions, Bessel functions and spherical harmonics.
(*e*) Elliptic functions.
(*f*) Calculus of Finite Differences.
(*g*) Quaternions.
(*h*) Philosophy of Mathematics.

(i) **Algebra.**—A good general survey is given in C. Smith's *Treatise on Algebra*, which includes a chapter on the theory of equations. For more advanced work, and proofs of such theorems as that every equation has a root, real or imaginary, Chrystal's *Algebra* should be consulted. This gives a very full account of the subject.

Special branches are dealt with in "Number" and "Theory of Numbers," *Encyclopædia Britannica*. Permutations, Combinations, and Probability are dealt with in Whitworth's *Choice and Chance*. *Algebraic Equations*, by G. B. Matthews (Cambridge Tracts), gives an introduction to Galois' theory. Muir's *Determinants* gives a full historical survey of the subject. For advanced *Theory of Equations* the most exhaustive work is that of Burnside and Panton.

(ii) **Trigonometry.**—The advanced parts of plane trigonometry are very well treated in E. W. Hobson's *Plane Trigonometry*. The chapters on complex quantities, infinite series and products, and exponential and hyperbolic functions should be well digested, special attention being paid to the articles on convergence of series.

For *Spherical Trigonometry* use book by Todhunter and Leathem.

(iii) **Geometry.**—A nice introduction to *Modern Pure Geometry* is given in Richardson and Ramsey's little book. A fuller treatment may be obtained in a work by R. Lachlan.

Geometrical Conics may be studied either from C. Smith's book, or that by Cockshott and Walters.

Analytical Geometry (two dimensions).—A good general treatment is given in S. L. Loney's text-book, or that of C. Smith. The latter contains a little on areal and tangential coordinates. The best book for an advanced student is, however, G. Salmon's *Treatise on Conic Sections*. The beauty of treatment, especially in the chapters on abridged notation, distinguish this book from all others. Invariants and co-variants, projection, and reciprocation all receive adequate treatment. Elementary projective geometry is given in A. G. Pickford's book. Matthews' treatise is more advanced, but all that is essential may be obtained from Salmon's Conics.

Higher Plane Curves.—Practically the only text-book is Salmon's, which gives exhaustive treatment. Frost's *Curve Tracing* will repay study.

Analytical Geometry (three dimensions). — A good introduction is to be obtained in C. Smith's *Solid Geometry*, after which the student should read Salmon's book, lately revised by R. A. P. Rogers.

Invariants and Co-variants may be studied from Salmon's works. Applications to equations are given in Burnside and Panton's *Theory of Equations*. See also *Quadratic Invariants of Differential Forms*, by J. E. Wright.

(iv) **Calculus.**—*Elementary.*—*Differential and Integral Calculus for Beginners*, by J. Edwards.

Advanced.—*Differential Calculus*, by J. Edwards. In the elementary book by the same author rigorous proofs of the more advanced theorems are not attempted. They are here given in full, and the whole subject is well covered. The chapters dealing with curves are particularly good.

Integral Calculus.—Todhunter's and Williamson's may be used together, each giving good treatment of certain sections of the subject. Special attention should be paid to methods of integration, and emphasis is again laid on the necessity of working a large number of examples. The differentiation of any function is comparatively easy, but facility in integration can only be obtained by long practice. It will be found that the integration of a (to the student) new function often depends on the choice of a proper substitution; in this the student is greatly aided by experience in the integration of similar types of function, and from such experience he will be able to judge the kind of substitution likely to be most effective. Memorising results of indefinite and of definite integrals of standard forms is important.

Lamb's *Infinitesimal Calculus* gives a good general treatment of both the differential and integral calculus, together with an introduction to differential equations. It is written more from a practical standpoint and is specially suitable for engineering students or students of physics or chemistry not requiring such rigorous proofs of the general theorems as are given in more purely academical works. A text-book covering a wider field is *Higher Mathematics for Students of Chemistry and Physics*, by J. W. Mellor. Other treatises which should be consulted are Harnack's *Differential and Integral Calculus*, that of de Morgan, and Picard's *Traité D'Analyse*.

Differential Equations, by A. R. Forsyth. Starting with differential equations of the first order, the general linear equation is next dealt with, after which comes a chapter on miscellaneous methods of solution. This earlier part is fairly straightforward; the later chapters, dealing with integration in series,

hypergeometric series, solution by definite integrals, partial differential equations, &c., are more difficult.

Having obtained a comprehensive general knowledge of the calculus, including ordinary differential equations, the student may proceed to specialise on one or more of the following advanced subjects:

Fourier's Series, &c.—These are fully treated in *Fourier's Series and Integrals*, by H. S. Carslaw. Part I of this work deals with the theory of infinite series, convergence of such series, and Fourier's series and integrals. Part II deals with the mathematical theory of the conduction of heat, following in part Fourier's classical work.

Spherical Harmonics.—Most advanced text-books on differential equations give a little attention to these important functions. A concise account is to be found in *Fourier's Series and Spherical Harmonics*, by W. E. Byerly. The different types of spherical harmonics are first dealt with. Then follow solutions of Bessel's, Legendre's, and Laplace's equations. Trigonometrical series are dealt with at some length, and, finally, methods of attacking problems which admit of solution by harmonics are given. A useful set of tables of various harmonic functions is included.

Bessel Functions.—A work dealing with these functions specially and with certain allied functions is that by Gray and Matthews.

Elliptic Functions.—A single chapter is given on this subject in Todhunter's *Integral Calculus*. An elementary treatment is to be found in a small treatise by A. Cayley, and a more complete account in *Elliptic Functions*, by A. G. Greenhill, which is the standard work.

Calculus of Finite Differences.—For a beginning the student should study *Elements of Finite Differences*, by Burn and Brown, afterwards reading the more advanced treatise by G. Boole.

Quaternions.—Sir W. R. Hamilton's monumental work on the *Elements of Quaternions* is the classical text-book, but a very good working knowledge may be obtained from *Quaternions*, by C. J. Joly, or *Elementary Treatise on Quaternions*, by P. G. Tait. J. G. Coffin's *Vector Analysis* presents the principal results, and gives a number of useful applications, but no attempt is made at rigorous proofs.

There are numerous advanced treatises, portions at least of which should be studied carefully by any honours student in conjunction with, or in succession to, the less complete treatment of the subjects dealt with which is given in other works studied. There are also a number of memoirs, such as the Cambridge Series of Mathematical Tracts, which are very illuminative on certain subjects which are little dealt with in ordinary works, and serve as an admirable introduction to new fields. A few of these tracts are given below: *Integration of Functions of a Single Variable*, by G. H. Hardy. *Quadratic Forms and their Classification by Means of Invariant Factors*, by T. J. I'A. Bromwich. *Axioms of Projective Geometry* and *Axioms of Descriptive Geometry*, by A. N. Whitehead. *Introduction to Study of Integral Equations*, by M. Bôcher. *Fundamental Theorems of the Differential Calculus*, by W. H. Young. *Orders of Infinity*, by G. H. Hardy. *The 27 Lines upon the Cubic Surface*, by A. Henderson. *The Twisted Cubic*, by P. W. Wood. *Complex Integration and Cauchy's Theorem*, by G. N. Watson. *Linear Algebras*, by L. E. Dickson. *The Definite Integral, its Meaning and Fundamental Properties*, by E. W. Hobson. *The General Theory of Dirichlet's Series*, by G. H. Hardy. *Pascal's Hexagon*, by H. W. Richmond.

Among the more advanced treatises are several on *Theory of Functions*. A selection should be made of the portions required, for in numerous cases there is a large amount of overlapping.

Theory of Functions of a Real Variable, by E. W. Hobson, deals with number, the theory of sets of points, transfinite numbers, functions of a real variable, integration, functions defined by sequences, and trigonometrical series. For general theory:—*Introduction to Theory of Analytical Functions*, also *Treatise on Analytical Functions*, by Harkness and Morley. *Pure Mathematics*, by G. H. Hardy. Subject-matter: real variables, functions of real variables, convergence of infinite series, and of infinite integrals, logarithmic and exponential functions of real variables, and general theory of logarithmic, exponential, and circular functions.

Modern Analysis, by E. T. Whittaker. Part I treats of complex numbers, theory of absolute convergence, fundamental properties of analytical functions, Taylor's, Laurent's, and Liouville's theorems, uniform convergence, theory of residues with application to the evaluation of real definite integrals, expansion of functions in infinite series, Fourier series, and asymptotic expansions. Part II is occupied with the properties of gamma, Legendre, hypergeometric, and Bessel functions, and their application to the equations of mathematical physics. Elliptic functions are also dealt with.

In addition to these may be mentioned the *Principles of Mathematics*, by Bertrand Russell. This deals with mathematics from the philosophical standpoint.

Much valuable mathematical knowledge is only available in the proceedings of the various learned societies, and in the collected papers of men like Lord Kelvin, Lord Rayleigh, J. Clerk Maxwell, Sir G. G. Stokes, A. Cayley, &c. These may be consulted in any good reference library, but at first the student would do well to confine himself to articles he specially needs,

leaving the rest until he has time to devote to mathematical research.

In the advanced parts of pure mathematics, particularly in the calculus, it is almost impossible to differentiate between what may be termed pure and what applied mathematics. Throughout the whole subject much is gained by studying applied mathematics together with pure mathematics. A large amount of the work outlined earlier in this article would be of little use if it were not to be employed in dealing with other departments of science. The student is accordingly strongly recommended to study some at any rate of the following subjects as soon as he has obtained the necessary knowledge to deal with them :

Mechanics, Hydrostatics, Hydrodynamics, &c. Astronomy, Mathematical Physics. The latter will be found of very great interest, including as it does some of the finest mathematical work ever known.

A. WILKINSON, B.Sc.

VII. PHYSICAL SCIENCE

APPLIED MATHEMATICS

Scope of Subject.—In this subject the methods and results of Pure Mathematics are used and applied for the purpose of investigating the phenomena presented to us by Nature. Through such investigations man has attained the use and control of forces hitherto undreamt of.

Needless to add, such a definition embraces practically every known science, but experience has shown that it is chiefly in the branches of Physics, Astronomy, and Mechanics that the application of mathematics has proved most fertile in results. As Physics and Astronomy form separate sections of this work, this will be devoted entirely to Mechanics, a subject which inquires into the behaviour of bodies under the action of mechanical forces. It is usual to subdivide Mechanics into *Statics* (dealing with forces so arranged that the body acted upon remains at rest) and *Dynamics* (dealing with the resulting motion of bodies under the action of forces).[1] *Hydromechanics*, subdivisible into Hydrostatics and Hydrodynamics, deals with the properties of fluids and their behaviour under mechanical forces, and is usually included under Mechanics.

In the following pages I shall assume a knowledge, on the part of the reader, of elementary algebra (at least the ability to solve a simple equation) and of the circular functions of an angle, such as the sine, cosine, and tangent.[2]

STATICS AND DYNAMICS

Three laws first enunciated by Newton, as long ago as 1687, form the basis of Mechanics.

Newton's Laws.—1. "Every body continues in its state of rest, or of uniform motion in a straight line, except in so far as it is compelled by external impressed forces to change that state."

2. "The rate of change of momentum is proportional to the impressed force, and takes place in the direction of the straight line in which the force acts."

3. "To every action there is an equal and opposite reaction."

Although no *direct* formal proof, either experimental or theoretical, of these laws can be advanced, yet they *are* proved daily in an indirect manner. The *Nautical Almanac*, for example, predicts numerous events four years ahead, events such as eclipses of the sun and moon, the times of tides, the positions of the sun at certain periods in certain latitudes, &c., and these predictions are *invariably correct*. As the calculations whereby they are obtained are based on Newton's laws, it is inconceivable that the laws themselves should be erroneous. Their invariable agreement with observation, calculation, and experiment must be accepted as sufficient proof of their accuracy.

Law 1.—"*Every body continues in its state of rest or of uniform motion in a straight line except in so far as it is compelled by external impressed force to change that state.*"

Uniform Motion.—By "uniform motion in a straight line" is meant motion which does not change in character, that is a motion which neither alters in speed nor changes in direction. Such a motion is, in scientific language, said to be one in which the *velocity remains constant.* The term "velocity" is popularly used as a synonym for "speed," but, scientifically, the word denotes more than mere speed; it implies *direction* as well as speed. A stone or weight tied to a string and whirled round in a circle may be moving with uniform speed, but it is not moving with uniform *velocity*, since its motion is constantly changing in direction. From the above law we must necessarily conclude that it is impossible for a body to be moving in a circular or curved path unless acted upon by some force. In the example just cited the force is supplied by the *tug* of the string on the hand. Were the string to break the stone would, in accordance with the above law, fly off at a tangent, in the

[1] The term Dynamics has recently come into general use to denote Mechanics, the subdivisions being termed Statics and Kinetics.

[2] See Trigonometry.

direction of the motion possessed at the moment the string gave way.

It is difficult for a fast moving vehicle to take a sharp curve. The tendency is to keep straight on, and a force in the direction of the "turn" is necessary to negotiate the curve successfully.

A cyclist in turning a corner has to bend over in the direction in which he is travelling. By thus throwing his weight on one side, he applies the necessary force to produce a deviation from the straight line motion.

The earth in the course of a twelvemonth moves round the sun in a path or "orbit," as it is called, which is practically a circle; the force which produces such a motion is supplied by the attraction constantly exerted by the sun on our planet. A ball thrown into the air will, in the course of its rise and fall (provided it is not projected vertically), describe a parabola (Fig. 1),

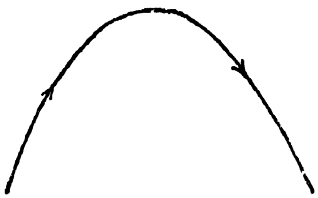


FIG. 1.

the force necessary to produce such a curved path being supplied by the constant attraction of the earth on the ball throughout its motion.

Force.—When a body is moving at a certain speed in a straight line—let us imagine a perfectly smooth ivory ball rolling on a smooth horizontal sheet of ice—it is inconceivable that such a body should of its *own accord* either increase or slacken its speed. We know from practical experience that the speed of the ball will gradually diminish, and we naturally seek for a *cause*. We know that, however smooth the ball and ice may be, there is still a little friction between them; the atmosphere also offers a small resistance. The friction and the resistance of the atmosphere are thus the "external impressed forces" which compel a change in "the state of uniform motion in a straight line" of the ball. If a stone be dropped from the top of a cliff, it will fall in a straight line, but its motion will not be uniform—it gathers speed on the way, so that at the end of one second it will be moving with a velocity of 32·2 ft. a second; at the end of two seconds its velocity will be 64·4 ft. a second, &c. Such a variable motion can only be due to an "external impressed force" acting on the stone; the force in this case is the familiar one known as "gravity," and is due to the "pull" or attraction exerted by the earth on the stone.

A body must either be at rest or in a state of motion—no intermediate state is conceivable—and Newton's First Law states that to produce a *change* in either of these states a *force* is necessary. "A change in the state of motion" does not necessarily mean merely a change from motion to rest, but includes a change in the *character* of the motion, that is a change either in speed or direction, or in both; in other words a change in velocity. The first law therefore defines *force* in so far as it describes its effects. (The second law, as we shall see later, takes us a step further, and gives us a means of measuring force.)

"Force" is therefore usually defined as *that which produces, or tends to produce a change in the state of rest or uniform motion of a body.* The words "tends to produce" are necessary to cover cases where a force is apparently inadequate to produce the implied change. For example, if I push against a wall, it does not move although a force is being exerted upon it, but it *tends* to move, the implication being that if it were not held in its place by other forces it *would* move.

Inertia.—The first law, stating as it does the reluctance of material bodies to change their state of rest or of uniform motion, is frequently known as the *Principle of Inertia.* Matter is said to possess *inertia,* which means that it requires the expenditure of a force to produce in a material body a change of state from rest to motion, from motion to rest, or from one form of motion to another. This is true of *all* matter, in every form and wherever found, whether in this world or in any other portion of the infinite universe. The principle of inertia is universal in the widest meaning of the term.

Our everyday experience provides innumerable examples of this Principle of Inertia. A horse is seen to experience great difficulty in *starting* a heavily-loaded truck, a great force being necessary to overcome the inertia, or reluctance of the matter contained in the truck to change its state of rest. Once started, however, but little force is required to keep it moving, that little force being the force necessary to counterbalance the forces of friction which play such a large and important part in our lives. Were these forces of friction absent, the truck would keep on moving for ever with the velocity originally imparted to it.

The "strap hanger" on the "Underground" finds himself jerked off his balance when the train suddenly starts. Being composed of matter, he must necessarily obey Newton's First Law and exhibit a reluctance to a quick change from a state of rest, and when the body of the carriage suddenly moves forward, he himself is left behind. The reverse process takes place when the brakes are violently applied—his material body insists on moving forward with the velocity it had attained just prior to the application of the brakes, and when the carriage is quickly brought to a standstill, he violently moves forward along the length of the carriage

in the direction of motion of the train—unless he holds fast to the strap.

The circus rider when he leaves his horse's back to jump through a hoop relies implicitly on "continuing in the same state of motion" during the time he is in the air, a state which the uniform motion of his horse had imparted to him before leaping.

There is no need to exemplify this Principle of Inertia any further. Numerous other examples will no doubt readily present themselves to the reader.

Graphical Representation of Velocity.—I will now consider "motion" in greater detail. The distinction between the popular term "speed" and the scientific term "velocity" has already been pointed out. In so far as a velocity implies both magnitude and direction, it can be graphically[1] represented by a straight line. A speed of 10 ft. a second may be represented by *any* straight line drawn to scale so as to represent a quantity 10, but a velocity of 10 ft. a second would be represented by a straight line drawn to scale as before, but drawn in the direction of the motion. A velocity of 10 ft. a second East, is therefore represented by the line AB (Fig. 2), (the arrow mark denoting the direction being added for the sake of greater precision), while a velocity of 20 ft. a second South would be denoted (on the same scale) by the line AC, twice as long as AB.

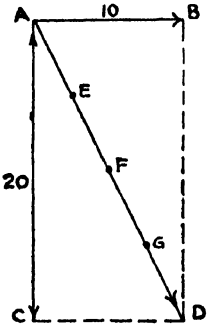


FIG. 2.

A quantity, like a velocity, which can be represented in magnitude and direction by a straight line is called a *vector* quantity.

A velocity is measured either in "foot per second" or "centimetres per second," according as the English or French unit of length is adopted. It may be here stated that, for scientific purposes, the French units are invariably used.

Parallelogram of Velocities.—A body frequently possesses more than one velocity. Let us suppose a ship travelling South with a constant velocity of 20 ft. a second, and a man runs across the deck Eastward (at right angles to the line of motion of the ship) at the rate of 10 ft. a second. He evidently possesses two velocities—that of the ship and that due to his own motion. What is his final or *resultant* velocity? At the end of a $\frac{1}{4}$ second he will have been carried 5 ft. South by the ship, and $2\frac{1}{2}$ ft. East by his own motion. Since AC and AB (Fig. 2) are drawn to scale to represent velocities of 20 ft. a second South and 10 ft. a second East, respectively, the man's position in *space* at the end of a $\frac{1}{4}$ second is represented by the point E. Similarly his position in space at the end of $\frac{1}{2}$ second is represented by the point F, at the end of $\frac{3}{4}$ second by the point G, and at the end of a second by the point D.

Evidently in one second he will have travelled *in space* along the line AEFGD. In other words, his resultant velocity is represented in magnitude and direction by the line AD, the diagonal of the parallelogram ABCD. This is true of *any two* velocities, *the resultant velocity being represented in magnitude and direction by the diagonal of the parallelogram, completed by drawing the remaining two sides equal and parallel to the two lines representing the two given velocities.* This is the principle known as the *parallelogram of velocities.* It is a mathematical method of adding two velocities not in the same line; a method which takes into account not merely the magnitudes of the speeds but also the directions of motion. The method is therefore applicable to all vector quantities—quantities which imply direction as well as magnitude.

Let AB, AC (Fig. 3) represent, in direction and magnitude, two velocities of 3 ft. a second and

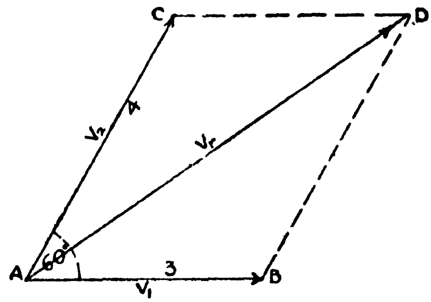


FIG. 3.

4 ft. a second respectively, and let the angle between their two directions be 60°. Complete the parallelogram by drawing CD parallel to AB and BD parallel to AC. The resultant velocity is then represented, in magnitude and direction, by the diagonal AD, whose length can be easily calculated. Thus

$$\begin{aligned} AD^2 &= AB^2 + BD^2 - 2AB.BD \cos \underline{/ABD} \\ &= 9 + 16 + 2.3.4 \cos \underline{/BAC} \\ &= 25 + 24 \times \tfrac{1}{2} \text{ (since } \cos 60° = \tfrac{1}{2}) \\ &= 37 \end{aligned}$$

$\therefore$ AD $= \sqrt{37} = 6{\cdot}08$ ft. a second (approximately).

Putting the calculation into a general form, if AB represents a velocity v_1, AC a velocity v_2, and the angle BAC an angle θ, then if v_r is the resultant velocity AD,

$$v_r^2 = v_1^2 + v_2^2 + 2v_1v_2 \cos \theta \quad . \ . \ . \ \textit{Equation (1).}$$

[1] The reader must not confuse a *graphical representation* with a *graph*. The former is a representation by means of a drawing, while a graph is a curve which is the locus of a number of points between the co-ordinates of which a definite constant relationship exists.

As an application of equation (1): A ship sailing eastwards with a velocity of 15 knots receives an additional velocity of 15 knots from a current, so that its resultant velocity is still 15 knots. What is the direction of the current ?

In this case v_1 and v_2 are each 15, and the resultant velocity, v_r, is still 15. Hence, substituting these values in equation (1) we have

$$15^2 = 15^2 + 15^2 + 2{\cdot}15{\cdot}15 \cos\theta$$
$$\therefore\ 2{\cdot}15^2 \cos\theta = -15^2$$
$$\therefore\ \cos\theta = -\tfrac{1}{2}$$
$$\therefore\ \theta = 120^\circ \text{ or } -120^\circ.$$

This is represented graphically in Fig. 4. AB represents the velocity of the ship, and AC

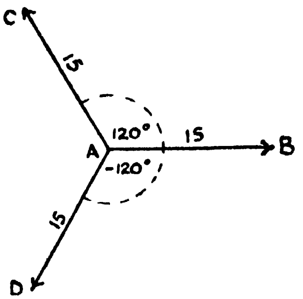


FIG. 4.

or AD would represent the velocity of the current, in both magnitude and direction. The direction of the current is therefore either 30° W. of North, or 30° W. of South.

A particular and important form of equation (1) is the case when θ is 90° and cos θ is, therefore, zero. In this case one velocity AB (Fig. 5) is at

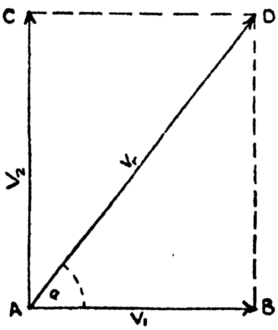


FIG. 5

right angles to the other AC, and equation (1) becomes $v_r^2 = v_1^2 + v_2^2$ . . . *Equation* (2).

Also the angle a which the resultant v_r makes with v_1 is given by, $\cos a = \dfrac{v_1}{v_r}$ . . . *Equation* (3).

To take a concrete example. A stream runs with a velocity of $1\frac{1}{2}$ miles an hour, while a man rows, in a direction *perpendicular* to the stream, with a velocity of 2 miles an hour. Required to find the velocity with which he crosses the stream. (This will include the direction of his crossing.)

v_1 and v_2 are $1\frac{1}{2}$ and 2 respectively, and *perpendicular* to each other. Equations (2) and (3) are therefore applicable.

$$\text{Hence } v_r^2 = \left(\frac{3}{2}\right)^2 + 2^2 = \frac{9+16}{4} = \frac{25}{4}$$
$$\therefore\quad v_r = \frac{5}{2}$$

Also cos (angle between direction of resultant velocity and that of stream) $= \dfrac{1\frac{1}{2}}{2\frac{1}{2}} = {\cdot}6$.

$\therefore$ Angle between direction of resultant velocity and that of stream $= 67^\circ$ (by reference to a book of mathematical tables).

He therefore crosses the stream with a velocity of 2·5 miles an hour, at an angle of 67° with the direction of the current.

Two velocities in the *same line* will of course add *algebraically*, the resultant velocity being equal in magnitude to the arithmetic sum (or difference) of the two, according as they are in the same direction or in opposite directions. If, for example, a man walks at the rate of 4 miles an hour along the length of the deck of a ship moving at the rate of 16 miles an hour, his resultant velocity is either 20 miles an hour or 12 miles an hour, according as he walks in the same direction or in a direction opposite to that of the motion of the ship. Similarly, any number of velocities in the same line may be added algebraically in order to find the resultant velocity.

Resolution of a Velocity into two Components.—Since two velocities can be compounded into one resultant velocity, it follows that any one velocity v_r can be resolved into two component velocities, v_1 and v_2 making any desired angle θ with one another. The most useful method of thus resolving a velocity is to do so into two velocities at right angles to each other.

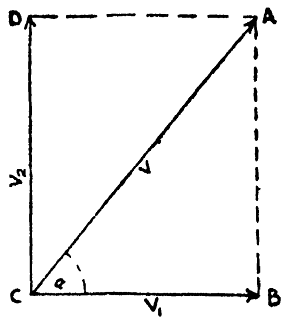


FIG. 6.

If a given velocity v be resolved into a velocity v_1, making an angle a with v (Fig. 6), and a velo-

city v_2 perpendicular to v_1, then v_1 and v_2 will be of such dimensions that v is the diagonal of a parallelogram of which v_1 and v_2 are two adjacent sides.

From the figure, it is evident that, $\frac{v_1}{v} = \cos \alpha$, and therefore $v_1 = v \cos \alpha$ . . . *Equation* (4).

Also $v_2 = AB$ and since $\frac{AB}{v} = \sin \alpha$, therefore $v_2 = v \sin \alpha$, or $v \cos \beta$ (if the angle ACD $= \beta$) . . . *Equation* (5).

Hence, resolving in the manner just described, we can express v_1 and v_2 in terms of the given velocity v and the given angle α.

The resolved part of a given velocity, in a given direction, is obtained by multiplying the given velocity by the cosine of the angle between the given velocity and the given direction.

As this is a very important method of treatment, the reader should make a special effort to master the principle.

Acceleration.—The velocities just dealt with under the Parallelogram Law, are "uniform" velocities—that is they do not change in direction or magnitude. If a velocity changes in magnitude, then it either increases or diminishes. In either case, the *rate of change* in the magnitude of a velocity is called an *acceleration*. If the change is an increase in velocity the acceleration is said to be positive, while a decrease in velocity is called a negative acceleration, or a *retardation*. If, for example, a body is at one moment moving with a velocity of 100 cm. per second, and one second later it is moving with a velocity of 120 cm. per second, the acceleration is 20 cm. per second in one second—written 20 cm. per sec. per sec. On the other hand a change in velocity in one second, from 100 cm. per second to 80 cm. per second, would be denoted by an acceleration of -20 cm. per sec. per sec. Like velocity, an acceleration may be either constant (*i.e.* uniform) or variable. If variable, the calculus method of infinitely small changes must be adopted, and for this reason I shall only deal in this article with uniform velocities and uniform accelerations.

An acceleration, like a velocity, can be represented in magnitude and direction by a straight line; it is a vector quantity. A body may possess more than one acceleration in more than one direction, and as with velocities, so two accelerations in two directions are equivalent to one resultant acceleration whose magnitude and direction is obtained by the parallelogram method just described. Further, an acceleration in any one direction may be resolved into two accelerations, making any required angle with each other. Equations (1) to (5) hold for accelerations as well as for velocites.

A good example of uniform acceleration is the case of a body falling freely under the action of gravity. All bodies fall to the earth at exactly the same rate. Aristotle taught otherwise, that heavy bodies fall faster than light ones. The first to apply a practical test was Galileo, and he demonstrated that Aristotle was wrong by dropping various weights, simultaneously, from the top of the Leaning Tower at Pisa. They all reached the ground at the same moment, proving that the acceleration was precisely the same for all. Exceptions *apparently* occur in the case of very light bodies, such as feathers, small pieces of paper &c., but even in their case, if precautions are taken to remove the resistance of the air, it is found that they fall at exactly the same rate as heavy bodies. The exact determination of the acceleration of a body falling vertically downward is a very important matter, and is carried out by means of pendulum experiments. The theory will be dealt with later. Here I will content myself with stating that the value of this acceleration, usually denoted by the symbol "g," varies a little at different places on the earth's surface, depending, as it does, on the distance of the place from the centre of the earth. In London, at sea-level, the value of g is 32·2 ft. per sec. per sec., or 981 cm. per sec. per sec.

Circular Motion.—If the velocity of a moving body changes in direction, as in the case of a body moving in a circle, its velocity, as has already been explained, is not uniform, although its "speed" may be. The difficulty is, in such a case, overcome by considering its *angular* velocity, and not its speed, in the path of motion. Take the case again of the stone tied to a string and whirled round in a circle. If at one moment the stone is at A, and the next moment at B (Fig. 7), then the stone is said to have described in that time an angle θ, measured by the angle AOB. Just as linear velocity (velocity in a straight line) is measured by the quotient

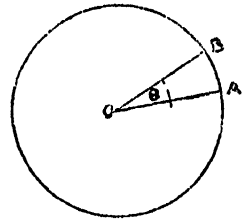


FIG.

$$\frac{\text{linear distance passed over}}{\text{time in which this is accomplished}},$$

so angular velocity is measured by the quotient

$$\frac{\text{angle described}}{\text{time in which this is accomplished.}}$$

In the above example, therefore, if τ denote a very short interval of time in which the angle θ has been described, and if w denote the angular velocity, then $w = \frac{\theta}{\tau}$. It can easily be proved that if s is the speed in the circle, and r the radius of the circle, then $s = wr$ [1] . . . *Equation* (6).

If the speed of the stone in the circle is uniform

[1] $s = \frac{AB}{\tau}$; $AB = r\theta$ $\therefore s = \frac{r\theta}{\tau} = rw.$

then, evidently, equal angles will be described in equal times, and the angular velocity will be uniform. In such motion we, therefore, deal with uniform *angular* velocities instead of uniform velocities dealt with in the case of motion in a straight line. Now the angular velocity may change, the circling motion becoming quicker or slower. The body is then said to possess an angular acceleration which is positive or negative, according as the angular velocity increases or decreases. And the angular acceleration, like linear acceleration, is measured by the *rate* of change of angular velocity. For example, if a wheel making three revolutions per second, is brought to rest in two seconds by the application of a brake, then the original angular velocity is 6π per sec. or 1080° per sec. (since a complete revolution implies the description of an angle of 2π or 360°), and as this angular velocity has been destroyed in 2 seconds, the rate of change of the angular velocity, *i.e.* the angular acceleration is -3π per sec. per sec., or $-540°$ per sec. per sec., the negative sign implying a diminution of velocity. The assumption just made is that the action of the brake is uniform throughout the 2 secs., but, as already stated, I shall confine myself entirely to uniform velocities and uniform accelerations.

Now if a body is moving with a velocity represented in magnitude and direction by the line AB (Fig. 8), and a *moment* later [1] is moving

FIG. 8.

with a velocity represented in magnitude and direction by the line AC (which we will suppose equal to AB), it follows, from the Principle of the Parallelogram of Velocities, that the velocity AC must be the resultant of the velocity AB together with some *other* velocity which has been, in some manner, created during that short interval. By means of that Principle we also know that this "other velocity" is represented in magnitude and direction by the line AD, which is equal and parallel to BC. If this velocity has been created in a time τ, then the rate of change of velocity, or the acceleration, of the body is given by $\dfrac{\text{length of AD}}{\tau}$, and the acceleration acts in the direction of A to D. Hence a body, in merely changing its direction of motion, although its speed remains the same, *is moving with a linear acceleration*, and for that reason its velocity is not uniform. This may perhaps be difficult for the beginner to grasp, but his difficulty will vanish if he will habituate himself to the thought that velocity implies direction as well as magnitude.

But a change in velocity, or an acceleration, can only, according to Law 1, be produced by an external impressed force, and, as we shall see later (from Law 2), this force is in the direction of the acceleration. It follows, therefore, that a body, originally moving in the direction AB, can only deviate into the direction AC (although still moving at the same speed) under the influence of a force acting in the direction AD, and the full meaning of Law 1 now becomes perfectly clear.

Let us now apply our new knowledge to the case of a body moving, with uniform speed s, in a circle, of radius r. The velocity of the body at some point, such as A (Fig. 9), is represented by

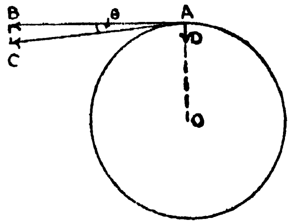


FIG. 9.

AB, drawn equal to s and a tangent to the circle at A. A moment later (after an interval τ) the velocity is represented by AC, also equal to s, and also a tangent to the circle at a point very close to A. The angle BAC—we will call it θ—is therefore very small. Now the linear acceleration of the body is given by $\dfrac{AD}{\tau}=\dfrac{BC}{\tau}$.

Since AB and AC are very close to each other and equal, BC will be perpendicular to both AB and AC; hence AD is perpendicular to the tangent AB. The acceleration (linear) is therefore *towards the centre O*. And since A is *any* point on the circle, the acceleration at every point in the path of the circular motion is directed towards the centre. It but remains to find the magnitude of this acceleration.

$$\text{Since } \frac{BC}{CA}=\sin\theta, \quad BC=CA\sin\theta.$$

When θ is very small, $\sin\theta=\theta$.

$$\therefore\ BC=CA\cdot\theta.$$

As CA represents in magnitude the speed s, $\therefore\ BC=s\cdot\theta$.

$$\therefore \text{ The acceleration}=\frac{AD}{\tau}=\frac{BC}{\tau}=\frac{s\theta}{\tau}.$$

But the angle θ is equal to the angular distance described in the circle itself.

$$\therefore\ \frac{\theta}{\tau}=w, \text{ and}$$

the acceleration $=sw$ or $\dfrac{s^2}{r}$ or w^2r . . . *Equation* (7).

(Since $s=wr$ by equation (6).)

If, for example, a stone tied to a string of length 3 ft. is whirled in a circle so as to make

[1] By a "moment later" is meant here the lapse of an infinitely small interval of time.

two revolutions a second, its angular velocity w is $2.2\pi = 4\pi$, and its acceleration (not angular, but linear, towards the centre of the circle) will be $w^2r = (4\pi)^2.3 = 48\pi^2$.

If π is taken as $\frac{22}{7}$, this becomes 474·1 ft. per sec. per sec.

Gravitation.—The force with which the Earth attracts every body near its surface is called *gravity*, and as already mentioned, this force is such as to produce an acceleration of g. It has been demonstrated beyond doubt that matter in every form exerts a force of attraction on other matter. This universal attraction of matter on matter is called *gravitation*, a general term which applies to all matter and hence to all heavenly bodies, and is to be distinguished from "gravity," which is used only to denote the Earth's attraction on matter. Now, the value of g is found to depend *inversely* on the distance separating a body from the Earth's centre; that is, the greater this distance the smaller is the value of g and, conversely, the smaller the distance the greater the value of g. Hence the attractive force between the Earth and any body must be inversely proportional to the distance separating the two. Equation (7), together with a knowledge of certain astronomical data, will enable us to find the precise nature of this inverse proportion. Thus the moon describes a circle whose radius is sixty times the Earth's radius, in 27·32 days. The Earth's radius is 3960 miles.

The angular velocity of the moon, w, is therefore $\frac{2\pi}{27{\cdot}32 \times 24 \times 60 \times 60}$. The radius "$r$" of the circle described is $60 \times 3960 \times 5280$ ft.

The acceleration of the moon towards the Earth's centre is, by (7), rw^2, which, by substituting the above values, works out to nearly ·009 ft. per sec. per sec. If now we assume that the acceleration varies inversely as the *square* of the distance, then the acceleration of the moon towards the Earth would be $\frac{g}{60^2} = \frac{32{\cdot}2}{60 \times 60}$ = nearly ·009 ft. per sec. per sec., which agrees exactly with the acceleration calculated from a knowledge of the moon's orbit and the Earth's radius. Hence the *force of gravity must vary inversely as the square of the distance*. A knowledge of the orbits of the planets enables a similar deduction to be made as regards the force of gravitation.

Important Equations of Motion.—Bodies fall to earth with uniform accelerations of 32·2 ft. per sec. per sec. If a body starts falling from a position of rest its velocity at the end of 1 sec. will be 32·2 ft. per sec.; in the next second it will have increased its velocity by another 32·2 ft. per sec., and hence its velocity at the end of 2 secs. will be $2 \times 32{\cdot}2$ ft. per sec.; at the end of 3 secs. its velocity will be $3 \times 32{\cdot}2$ ft. per sec., and so on for every second of its fall. Putting this in general terms, if v is the final velocity of a body starting from rest and moving for t seconds with a uniform acceleration f, then $v = ft$. And if such a body starts, not from rest, but with an initial velocity u, then

$$v = u + ft \quad . \; . \; . \quad \textit{Equation } (8).$$

Now to find the distance s moved through by such a body in time t. The initial velocity being u, the final velocity $u+ft$, and the acceleration constant, the *average* velocity throughout that time must be $\frac{u+(u+ft)}{2} = u + \frac{1}{2}ft$. And since the body has been moving for t seconds with this average velocity, the distance $s = (u + \frac{1}{2}ft)t$, and therefore $s = ut + \frac{1}{2}ft^2$ . . . *Equation* (9).

It should be noted that the average velocity is $u + \frac{1}{2}ft$, because the acceleration is uniform. Similarly, $v = u + ft$, because the acceleration is uniform. Hence both equations (7) and (8) only hold for cases of motion with *uniform acceleration*.

From equations (8) and (9) we can eliminate t thus:

Square (8) then $v^2 = u^2 + 2uft + f^2t^2$.
$= u^2 + 2f\,(ut + \frac{1}{2}ft^2)$.

Substitute from (9), then

$$v^2 = u^2 + 2fs \quad . \; . \; . \quad \textit{Equation } (10).$$

Let us consider a few simple applications of the last three equations:

Example 1.—A cricketer throws a ball vertically upward with a velocity of 80 ft. a second. Assuming the acceleration due to gravity to be 32 ft. per sec., what is the greatest height to which it will rise, and for how long will it continue rising?

The ball will evidently continue rising until its final velocity is zero. Hence we know v, u, and f. We require a knowledge of s; consequently equation (10) is applicable, viz.:

$$v^2 = u^2 + 2fs.$$
$$\therefore \quad 0^2 = 80^2 - 2.32.s.$$
$$\therefore \quad s = 100 \text{ ft.}$$

Note the negative sign, due to the fact that the acceleration f is a *retardation*.

We next require a knowledge of t. Hence apply equation (8), viz:

$$v = u + ft.$$
$$\therefore \quad 0 = 80 - 32t.$$
$$\therefore \quad t = 2\tfrac{1}{2} \text{ secs.}$$

Example 2.—The speed of a train is reduced from 40 miles an hour to 10 miles an hour, during which time it travels 200 yds. If the retardation is uniform, how much farther will it travel before coming to rest?

40 miles an hour $= \frac{176}{3}$ ft. a sec.; 10 miles an hour $= \frac{44}{3}$ ft. a sec.; 200 yds. = 600 ft.

Equation (10) gives $\left(\frac{44}{3}\right)^2=\left(\frac{176}{3}\right)^2+2\cdot f\cdot 600$.

$\therefore\ f=\left(\frac{44}{3}\right)^2\left\{1-4^2\right\}/1200$.

$\therefore\ f=-\frac{121}{45}$ (the negative sign denotes a retardation).

Applying equation (10) again: the initial velocity being now 10 miles an hour and the final velocity zero, we have:

$$0^2=\left(\frac{44}{3}\right)^2+2\cdot f\cdot s.$$

$$0^2=\left(\frac{44}{3}\right)^2-2\cdot\frac{121}{45}s.$$

$s=40$ ft., which is the required distance.

Example 3.—If a body slides down a *smooth* inclined plane making an angle θ with the horizontal, the acceleration down the plane will be $g\sin\theta$. For if B (Fig. 10) represent the position

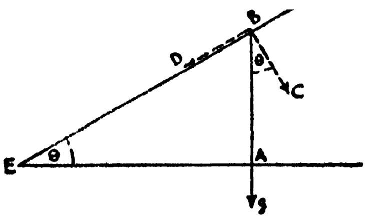


FIG. 10.

of the body at any instant during its motion, then its acceleration is g vertically downward (in the direction BA). But this acceleration can be resolved into two accelerations, (Parallelogram Principle for vector quantities, see p. 546), one in the direction BC perpendicular to the inclined plane and one in the direction BD *along* the plane, and it is this last which has the effect of increasing the speed of the sliding body. Now the angle ABC = angle AEB = θ.

$\therefore$ the acceleration in direction BC $=g\cos\theta$ (*cf.* equation 4).

And since BD is perpendicular to BC, the acceleration in direction BD $=g\sin\theta$ (*cf.* equation 5). If, for example, the inclination of the plane to the horizontal is 30°, then $\sin 30°=\frac{1}{2}$, and the acceleration of a body sliding down such a plane would be $\frac{1}{2}g$, or $\frac{1}{2}$ that with which a body falls vertically downward.

Equations precisely similar in form to equations (8), (9), and (10) hold for motions of rotation, but with *angular* velocity, *angular* acceleration and *angular* distance substituted for linear velocity, linear acceleration and linear distance. If w_0 is the initial angular velocity of a rotating body, such as a wheel for example, w the final angular velocity, a the uniform angular acceleration, θ the angular distance described in time t, then

$$w=w_0+at \quad \ldots\ldots \quad \textit{Equation } (8')$$
$$\theta=w_0t+\tfrac{1}{2}at^2 \quad \ldots\ldots \quad \textit{Equation } (9')$$
$$w^2=w_0^2+2a\theta \quad \ldots\ldots \quad \textit{Equation } (10')$$

For example: a wheel making 3 revolutions a second is brought to rest, by the application of a brake, in $1\frac{1}{2}$ seconds. How many revolutions will it make during the time the brake is applied, assuming the retardation to be uniform?

A complete revolution implies an angle of 2π. Hence $w_0=6\pi$; also w is zero. Applying (8′):

$$0=6\pi+a\cdot\frac{3}{2}.$$

$$\therefore\ a=-4\pi,$$

which means that the retardation is at the rate of 2 revolutions per second.

Now apply (9′):

$$\theta=6\pi\cdot\frac{3}{2}-\frac{1}{2}\cdot 4\pi\cdot\left(\frac{3}{2}\right)^2$$

$$\therefore\ \theta=9\pi-\frac{9\pi}{2}=\frac{9}{2}\pi=2\tfrac{1}{4}\text{ revolutions.}$$

The Simple Pendulum.—Suppose a particle P attached to one end of a weightless string of length l, the other end of which is fixed to a point O, so that the particle is capable of oscillating in an arc which forms part of a vertical circle (Fig. 11). Such an arrangement,

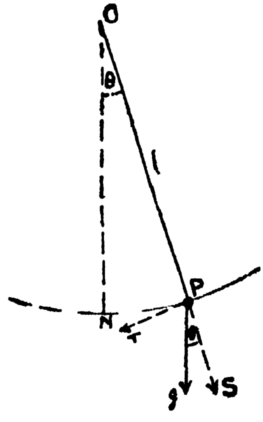


FIG. 11.

called a *Simple Pendulum*, is ideal, and cannot be obtained in practice. Now let the particle be displaced from its natural position of rest (at a point N vertically below O), so that the string makes a small angle θ with the vertical, as illustrated, and then let the particle be released. In the succeeding motion, the acceleration of P is g vertically downward. This resolves into an acceleration $g\cos\theta$ in the direction PS (the line of the string produced), and an accelera-

tion $g \sin \theta$ in the direction PT, at right angles to PO and hence tangential to the circle.

If θ is a small angle

$$\sin \theta = \theta = \frac{\text{arc PN}}{\text{OP}} = \frac{\text{distance of P from N}}{l}.$$

Hence the acceleration of the particle at any point in its swing is equal to $g \times \frac{s}{l}$, where s represents the distance of the particle from N, its position of equilibrium. When the particle is at the extreme end of its swing, at P, "s" is a maximum, and the acceleration is therefore greatest at the commencement of the swing or oscillation; as s decreases, the acceleration decreases proportionately, and is zero at the moment the particle passes N; as it moves to the left of N, s increases negatively, and the acceleration consequently increases negatively until the second extreme end of the swing is reached, when the acceleration is again a maximum, but with negative sign. The reverse is the case with regard to the velocity of the particle. The velocity is zero, a minimum, at the commencement of the swing, and as the motion is accompanied by an acceleration, though a diminishing one, the velocity must necessarily increase to a maximum at N. After passing this point the acceleration becomes negative, and the velocity will necessarily decrease until it is again zero at the other extreme end of the swing.

Such an oscillatory motion of a particle backward and forward about a central point, and during which the acceleration varies directly as the distance from the central point, is called *Simple Harmonic Motion.*[1] The range of the motion on either side of the central point is called the *Amplitude,* and the time of a *complete* oscillation, by which is meant the time of the motion from one extreme end to the other and *back again,* is called the *Periodic Time* of the motion. Simple Harmonic Motion occurs in many natural phenomena, and its study has led to very important results. Any attempt to deal with it would involve advanced mathematics beyond the scope of this article. I will content myself with quoting one important result, which the reader must take "on trust," viz. if a particle moves with Simple Harmonic Motion, the acceleration at any point in its path being μs, where s is the distance of that point from the central position and μ is a constant, then the Periodic Time T, of the motion, is given by, $T = \frac{2\pi}{\sqrt{\mu}}$.

[1] The path of the motion need not necessarily be an arc of a circle, as in the case of the Simple Pendulum. If a weight, for example, be suspended from a spring in a vertical position, pulled down slightly and released, it will oscillate up and down in a *straight* line about a central point, and its acceleration will vary directly as the distance from the central point. Its motion is therefore Simple Harmonic.

The motion of a simple pendulum approximates very closely to Simple Harmonic Motion, provided the Amplitude or extent of the swing is very small. The acceleration being $\frac{g}{l} \cdot s$, the quantity $\frac{g}{l}$ takes the place of μ in the last expression, and the time of a complete oscillation (the time taken in swinging from rest to rest and *back again*) is

$$T = \frac{2\pi}{\sqrt{\frac{g}{l}}} = 2\pi\sqrt{\frac{l}{g}} \quad . \quad . \quad \textit{Equation (11)}$$

The longer the string, the greater will be the value of T, and therefore the slower will be the motion.

From an accurate measurement of l and exact timing of the swing, we can calculate, by means of the last equation, the value of g at the spot where the experiment is carried out. Now g varies inversely as the square of the distance from the centre of the earth, and if we evaluate g at sea-level and also at a known height, h, above sea-level, we can calculate the radius of the earth. For example, let g_1 be the value of g at sea-level (a distance r from the earth's centre), and g_2 the value of g at a height h above sea-level;

$$\text{then } \frac{g_1}{g_2} = \frac{(r+h)^2}{r^2} = \frac{r^2+2hr+h^2}{r^2}$$

$$= \left(1+\frac{2h}{r}\right) \text{ approximately} = \frac{r+2h}{r},$$

$$\text{or} \qquad r(g_1-g_2) = 2hg_2, \text{ and } \therefore \ r = \frac{2hg_2}{g_1-g_2}$$

If, for example, the value of g at sea-level is 32·2, and at a height of 2 miles above sea-level it is found to be 32·168,

$$\text{then} \qquad \frac{2 \times 2 \times 32{\cdot}168}{{\cdot}032} = 4{,}021 \text{ miles.}$$

The apparently difficult task of accurately measuring the dimensions of the Earth is thus performed by careful timing of the swing of a simple pendulum.

The words "Simple Pendulum" must be noted, since the whole argument depends on that. Unfortunately, however, we cannot obtain a simple pendulum, since a weightless string and a particle of no dimensions are practical impossibilities. We can approximate to it by having a very thin wire and a very small bob, but even such an approximation would not result in the degree of accuracy attained by modern science.

Kater's Pendulum.—Captain Kater solved the difficulty in 1817 in the following manner. He constructed a pendulum, since known by his name, which consisted of a long iron bar having

a bob B, near one end (Fig. 12). It had two knife edges, E_1 and E_2, so that it could be swung on E_1, or inverted and swung on E_2. Between these edges were two adjustable weights, W and w, which could be moved up and down the bar and screwed into any required position. The larger weight W, was first moved about until the times of swing about E_1 and about E_2, respectively, were *nearly* equal, when it was screwed into position. The smaller weight, w, was then moved until *exact* equality in the times of swing from the two knife edges was obtained. It can be demonstrated mathematically that in such a case the *time of swing is exactly equal to that of a simple pendulum whose length is equal to the distance between the knife edges.* The formula $T=2\pi\sqrt{\frac{l}{g}}$ can now be applied, and the difficulty of an ideal and unpractical pendulum disappears: g can now be calculated with a great degree of accuracy, and from it other valuable scientific data obtained.

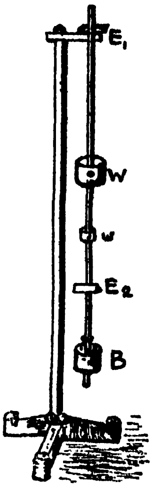


FIG. 12.

Parallelogram of Forces.—Having considered the effect of a force, viz. to produce a positive or a negative acceleration, I will turn to a consideration of "force" itself, apart from its effects.

It will be admitted that a force may vary in magnitude and in its line of action, *i.e.* in direction. That being the case a force is a vector quantity, which may be represented in magnitude and direction by a straight line. Further, a force has a definite point of application, and is thus a localised vector. The line drawn to represent a force must therefore pass through the point of application of the force. If we consider merely a particle P acted upon by two forces, the graphical representation of these forces will be two lines, PA and PB, which meet at P (Fig. 13). Forces being vector quantities,

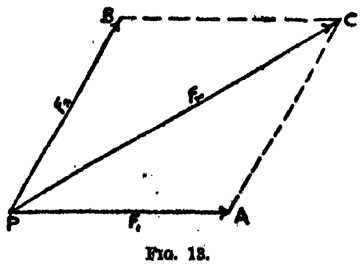


FIG. 13.

the Parallelogram Principle is applicable, and the *resultant* effect of the two forces, represented by PA and PB, is a single force represented in magnitude and direction by PC, the diagonal of the parallelogram PBCA. The value of PC is given by equation (1), in which the letters F_1, F_2, and F_r, to represent the forces PA, PB and PC, should be substituted for v_1, v_2, and v_r.

Resolution of a Force into Two Components.—It also follows that any force, such as PC, can be resolved into two forces at right angles to each other, and in any required directions, the magnitude of these forces being given by equations (4) and (5). If, for example, a weight of 30 lb. is placed on an inclined plane whose length is 5 ft. and having one end 4 ft. above the level ground, the weight of 30 lb., which is equivalent to a force which we will call 30, acts vertically downward in the direction PA (Fig. 14).

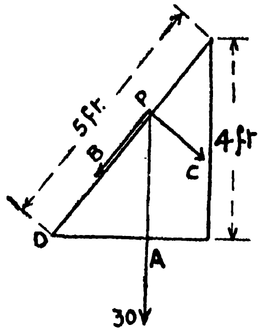


FIG. 14.

This force can be resolved into a force, 30 cos $\underline{|APB}$, acting in the direction PB, and a force, 30 cos $\underline{|APC}$, acting in the direction PC. Since DAP is a right-angled triangle, cos $\underline{|APB}$ $=\sin \underline{|ADP}=\frac{4}{5}$.

Also $\underline{|APC}=\underline{|ADP}$, $\therefore$ cos $\underline{|APC}=\cos \underline{|ADP}$ $=\frac{3}{5}$ since the base of the inclined plane $=\sqrt{5^2-4^2}=3$.

Hence the force acting down the plane is $\frac{4}{5}$ of $30=24$ lb. weight, which is the magnitude of the force causing the weight of 30 lb. to slide down; also the pressure or weight on the plane is $\frac{3}{5}$ of $30=18$ lb. weight.

Another example. A truck is at rest on a railway line, and is pulled by a horizontal force equal to a weight of 80 lb. in a direction making an angle of 60° with the direction of the rails; what is the force tending to urge the truck forward?

If T represents the truck (Fig. 15), the force of 80 lb. weight can be resolved into a force of 80 cos $60°=80\times\frac{1}{2}=40$ lb. weight along the rail (and this will be the force tending to urge the truck forward), together with a force 80 sin 60° $=80\times\frac{\sqrt{3}}{2}=\frac{\sqrt{3}}{40}$ lb. weight perpendicular to the rail, tending to pull the truck off the rails.

This last force will be counterbalanced by the action of the rails on the flanges of the wheels with which the rails are in contact.

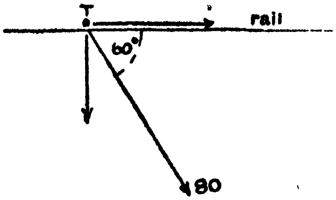


Fig. 15.

The "tacking" of a sailing vessel when sailing against the wind is a practical method of resolving the force of the wind, so as to provide a force in the desired direction.

Let K′AK represent the direction of the keel of the boat (Fig. 16), and WA the direction of the wind, the desired direction of "sailing" being AK. Let AS represent the sail; consider any point P on the sail. The action of the wind is in the direction RP with a force which we will suppose to be F. This force may be resolved into (*a*) a component along the sail in the direction PA, and (*b*) a component perpendicular to the sail in the direction PQ. The former has no effect on the boat. The latter causes the "tilt" from the upright seen in a sailing boat, and further resolves into two components, (1) in the direction PT parallel to AK, thus providing a force which produces

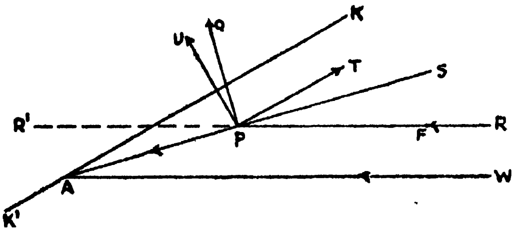


Fig. 16.

motion in the desired direction, and (2) in the direction PU, perpendicular to AK, which produces a motion sideways, termed by sailors "lee-way."

Unless the direction of the sail AS is such as to fall *between* AK and AW, *i.e.* between the direction of the keel and that of the wind, the component force of the wind along the keel will be in the direction AK′ instead of AK. The reader can prove this for himself by means of a figure, drawing the sail outside the angle WAK, and resolving the force of the wind in the manner just described.

Naturally, forces acting in the same line add algebraically. Thus forces of 3 and 5, both acting in the same direction, are equivalent to one resultant force of 8 in that direction, whereas if acting in opposite directions, the resultant is a force of 2, acting in the direction of the larger force. Parallel forces acting in the same directions are called *like* forces, while parallel forces acting in opposite directions are called *unlike* forces. Algebraic addition will therefore give the resultant of any number of like and unlike forces.

The method of resolving any one force into two forces at right angles to each other enables us to find the resultant of *any* number of forces acting at a given point. To take a concrete example as an illustration. Forces of 3, 4, and 5 act at a point P in the directions illustrated in the figure. It is required to find the magni-

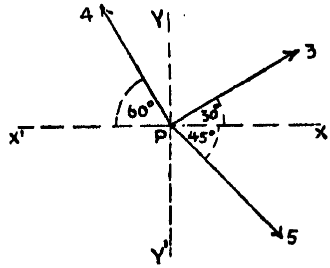


Fig. 17.

tude and direction of the resultant of these forces.

First resolve each force into two forces, in directions at right angles to each other. Thus:

Force 3 resolves into a force $3 \cos 30° = \frac{3\sqrt{3}}{2}$ in direction PX, together with a force $3 \sin 30° = 3 \times \frac{1}{2}$ in direction PY.

Force 4 resolves into a force $4 \cos 60° = 4 \times \frac{1}{2}$ in direction PX′, together with a force $3 \sin 60° = \frac{3\sqrt{3}}{2}$ in direction PY.

Force 5 resolves into a force $5 \cos 45° = \frac{5}{\sqrt{2}}$ in direction PX, together with a force $5 \sin 45° = \frac{5}{\sqrt{2}}$ in direction PY′.

Adding, algebraically, all the forces in the direction X′X, we get $\frac{3\sqrt{3}}{2} - 2 + \frac{5}{\sqrt{2}} = 4{\cdot}2$ nearly.

Adding, algebraically, all the forces in the direction Y′Y, we get $\frac{3}{2} + \frac{3\sqrt{3}}{2} - \frac{5}{\sqrt{2}} = {\cdot}6$ nearly.

Hence the given forces are equivalent to a force of 4·2 in the direction PX, together with a force of ·6 in the direction PY.

We next find the resultant R (Fig. 18) of these two forces by the Parallelogram Law, viz. $R = \sqrt{(4{\cdot}2)^2 + ({\cdot}6)^2} = \sqrt{18}$, and the direction of

this resultant force is such as to make an angle θ with PX, given by, $\tan\theta = \frac{\cdot 6}{4 \cdot 2} = \frac{1}{7}$. Referring to a book of mathematical tables, we see that $\theta = 8^\circ\ 8'$ nearly.

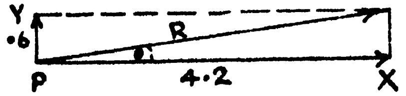


FIG. 18.

From the principle of the parallelogram of forces, two very important deductions can be made.

(a) *The Principle of the Triangle of Forces.*—Suppose two forces, represented by PA and PB, act at a point P (Fig. 19). Their resultant is represented by PD. If there is a third force acting at P, which is represented by PC, this force being exactly equal and opposite to PD, it follows that the resultant of the three forces, PA, PB, and PC, is zero. The particle is, in such conditions, said to be in *equilibrium* under the action of the three forces; the particle will not alter its state of rest or of uniform motion, since the forces are such as to exactly counterbalance each other. Now the three forces PA, PB and PC are represented in magnitude and direction (though not as regards point of application) by the sides of the triangle PAD, the directions being P to A, A to D, D to P—the same way round the triangle.

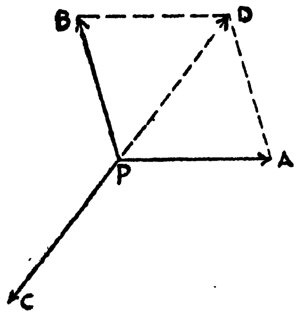


FIG. 19.

Hence if three forces are in equilibrium they can be represented in magnitude and direction by the three sides of a triangle *taken in order*. Conversely, if three forces *can* be represented in magnitude and direction by the three sides of a triangle taken in order, they must be in equilibrium. The last two statements constitute the principle of the triangle of forces. It follows immediately from this principle, that if three forces acting *in a plane* (not at one point) are in equilibrium, their lines of action must either meet at a point or be parallel. For, if they are not parallel, the lines of action of two of them must meet at some point, and in order to balance the resultant of these two, the third force must not only be equal and opposite to this resultant, but must be in the same line. Hence the line of action of the third force must pass through the point of intersection of the lines of action of the other two.

An example or two will illustrate the valuable application of which this principle is capable.

Example 1.—A weight of 39 lb. is suspended by two strings, 5 and 12 feet in length respectively, the strings being attached to two points in the same horizontal line, 13 feet apart. Find the tensions in the string.

Draw a horizontal line AB, 13 units in length. With centre A and radius 5 units, draw an arc of a circle, and with centre B and radius 12 units draw another arc. The intersection C of these two arcs gives the position of the weight (Fig. 20).

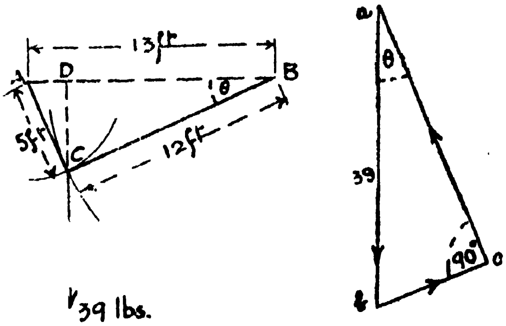


FIG. 20.

The point C is in equilibrium under three forces, viz. a force of 39 lb. vertically downward, the tension in the string CA acting in that line, and the tension in the string CB acting in its line. Hence the three forces acting at the point C can be represented, in magnitude and direction, by the three sides of a triangle taken in order. Draw a vertical line *ab*, 39 units in length, to represent the weight. From "*a*" draw a line *ac* parallel to AC, and from *b* a line *bc* parallel to CB. *ac* and *bc* will then represent, in magnitude and direction, the tensions in AC and CB respectively, and a careful measurement of *ac* and *bc* will give us the values of these tensions, viz. 36 lbs. and 15 lbs. Further, the weight acts in the direction *a* to *b*, and as the forces must go round the triangle in order, the other two are in the directions *b* to *c* and *c* to *a*. This, translated to the strings themselves, would be in the directions C to B and C to A.

This method of solution is called a *graphical* solution, it being obtained by the actual measurement of the sides of the triangle *abc*. The degree of accuracy of the solution depends on the accuracy of drawing and measurement, but despite this drawback the graphic method is a very valuable one.

Let us now solve the problem analytically. We still make use of the principle of the triangle of forces, drawing the triangle abc as before, but we need not trouble about the accuracy of the drawing as long as we bear in mind that ab is *supposed* to be 39 units in length, and bc and ac are *supposed* to be parallel to CB and AC respectively. Let $ac = T_1$ and $bc = T_2$.

Since $13^2 = 5^2 + 12^2$, therefore the angle ACB (preceding figure) is a right angle, and consequently the angle acb is also a right angle.

Also $\quad \angle bac = \angle ACD$,

and since $\angle ACD + \angle DCB = 90° = \angle ABC + \angle DCB$,

$\therefore \quad \angle ACD = \angle ABC = \theta$, say $= \angle bac$.

Further, $\quad \angle abc = \angle DCB = (90° - \theta)$.

Now, in trigonometry it is proved that the sides of a triangle are proportional to the sines of the angles opposite them.

Hence $\dfrac{ab}{\sin 90°} = \dfrac{bc}{\sin \theta} = \dfrac{ac}{\sin (90° - \theta)}$

But $ab = 39$; $\sin 90° = 1$; $bc = T_2$; $ac = T_1$; $\sin (90° - \theta) = \cos \theta$.

$$\therefore \quad \frac{39}{1} = \frac{T_2}{\sin \theta} = \frac{T_1}{\cos \theta}.$$

And from the right-angled triangle ABC we see that $\sin \theta = \dfrac{5}{13}$, and $\cos \theta = \dfrac{12}{13}$.

$$\frac{39}{1} = \frac{T_2}{\frac{5}{13}} = \frac{T_1}{\frac{12}{13}}.$$

$$T_2 \text{ or } bc = \frac{5}{13} \text{ of } 39 = 15,$$

and $$T_1 \text{ or } ac = \frac{12}{13} \text{ of } 39 = 36.$$

Example 2.—A rod, whose weight W may be supposed to act at a point which divides the length of the rod in the ratio 3 : 2, is suspended from a small, smooth peg by a string 7 feet in length. Find the position of equilibrium assumed by the rod.

Let AB represent the rod, O the peg, C the

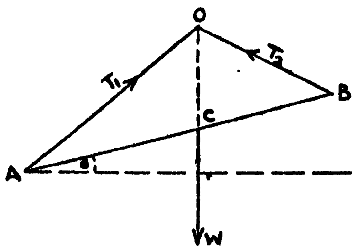


FIG. 21.

point at which the weight of the rod is supposed to act (Fig. 21). The system is in equilibrium under three forces, viz. the weight W, and the tensions T_1 and T_2 in the portions AO and BO of the string. But these three forces do not act at one point—they act in a plane; and doing so, their lines of action must meet at a point (Principle of Triangle of Forces). Since the lines of action of two of them, viz. of T_1 and T_2, intersect at O, the line of action of the force W must also pass through O. Hence C must be vertically below O, and the rod will assume such a position accordingly.

A more satisfactory solution, however, is to find the lengths of the portions AO and BO of the string.

As the string passes round a *smooth* peg, the latter can exert no force on the tension of the string at the point of contact. The tension, therefore, remains unaltered throughout the string, and $T_1 = T_2$. Since W balances the resultant of two equal forces, it must, by the parallelogram of forces, bisect the angle between them. Hence CO bisects the angle AOB. If $AO = x$ and $BO = y$.

Then $\dfrac{x}{y} = \dfrac{AC}{CB} = \dfrac{3}{2}$. [Euclid, Bk. VI., prop. 3.]

Also $\quad x + y = 7$.

Solving these two equations, we have

$$\frac{x}{3} = \frac{y}{2} = \frac{x+y}{5} = \frac{7}{5}$$

$$\therefore \quad x = \tfrac{21}{5} = 4\tfrac{1}{5} \text{ ft., and } y = \tfrac{14}{5} = 2\tfrac{4}{5} \text{ ft.}$$

The system will therefore assume such a position that the c.g. of the rod is exactly below the point of suspension, the lengths of the portions of string between the ends of the rod and the peg being $4\frac{1}{5}$ feet and $2\frac{4}{5}$ feet.

A more complete solution to the problem would be to find the angle θ which the rod makes with the horizontal, but to do so a knowledge of trigonometry is required beyond the assumptions made for the purpose of this article.

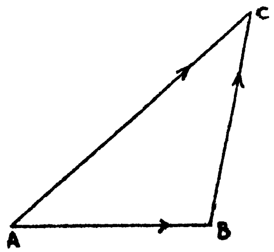


FIG. 22.

Since three forces acting at a point and represented in magnitude and direction by the sides of the triangle ABC, taken *in order*, are in equilibrium, it follows that the resultant of two forces, represented by AB and BC, must be equal in magnitude to a force represented by AC (Fig. 22), which must act in direction A to C. An extension of this leads to—

(b) ***The Principle of the Polygon of Forces.—If***

any number of forces acting on a particle can be represented, in magnitude and direction, by the sides of a polygon taken in order, the forces will be in equilibrium.

Let the sides AB, BC, CD, DE, EF, FA of the polygon (Fig. 23) represent in magnitude and direction the forces B, C, D, E, F, A acting on a particle O.

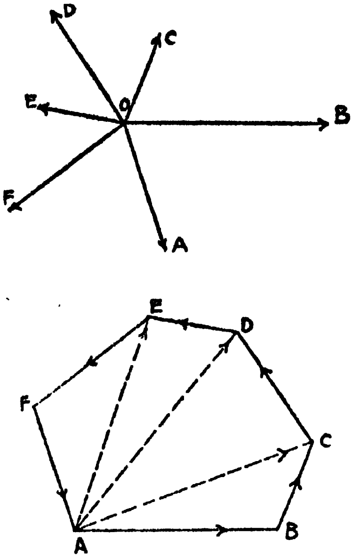


FIG. 23.

The resultant of the forces represented by AB and BC is a force represented in magnitude and direction by AC.

The resultant of AC and CD is AD.

" " AD " DE " AE.

The resultant of AE and EF is AF, and

" " AF " FA " zero.

Hence the forces are in equilibrium.

The proof is similar whatever the number of forces, and does not necessitate the sides of the polygon being in the same plane.

The converse of the Polygon of Forces is *not* true.

Moments and Couples.—Consider the case of two equal, unlike parallel forces P and Q, *not* in the same line, acting on a body B entirely free to move (Fig. 24). The linear resultant of these two forces is zero, but it does not follow that the body remains at rest under the forces P and Q. Were their action in the same line they would cancel each other, and the body would remain in equilibrium, but that not being the case, their effect is to produce a twisting motion, a motion of rotation about some line or point in the body, situated midway between the two forces. Two such equal, unlike, parallel forces are said to form a *couple*. No single force, acting on a body entirely free to move, can produce a rotatory motion such as a couple does, but if the body is pinned, or held, at a line a single force will produce a motion of rotation about this line. If I push with a force P.

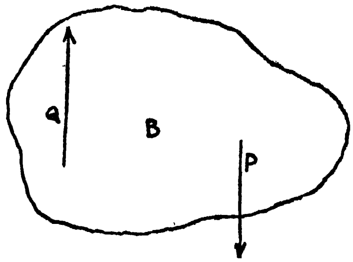


FIG. 24.

against a bar pinned at the line AB (Fig. 25), it will swing away from me in the direction of the arrow. Common experience shows that the effect of the force depends not only on its magnitude P, but also on its perpendicular distance *d* from the axis of rotation. Its effect is therefore measured by the product P . *d*, which is called the *moment* of the force about the axis of rotation. Further, such a moment is termed *positive* if it produces, or tends to produce, a rotation in an anti-clockwise direction, and *negative* if it produces, or tends to produce, a rotation in a clockwise direction. Equal moments in opposite directions will cancel each other, and thus the resultant moment of any number of forces about any point or line is found by algebraic addition of the moments of all the forces about that point or line.

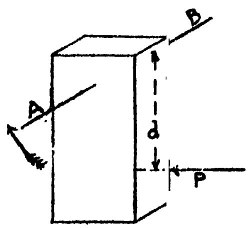


FIG. 25.

For Example.—A man carries a bundle at the end of a stick, which is placed over his shoulder. How does the pressure on his shoulder change with the position of his hand ?

Let BH represent the stick (B being the position of the bundle, which we will suppose weighs W lb.), S the shoulder, and H the position of the hand which exerts a downward pressure of P lb. Let x be the distance of the bundle from the shoulder, and y that of the hand. Since the system balances about S, the resultant moment about S is zero ; hence the

algebraic sum of the moments of the forces, W and P, about S must be zero, $\therefore\ Wx-Py=0$. (Note the sign attached to the moment Py; it

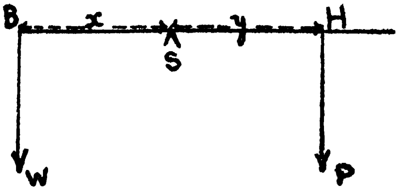


FIG. 26.

is negative, because the moment tends to produce rotation in a clockwise direction.)

From this equation $P=W\frac{x}{y}$.

The resultant of P and W

$$=P+W=W\frac{x}{y}+W=W\left(1+\frac{x}{y}\right),$$

which is the pressure on the shoulder. Assuming the bundle in a fixed position, i.e. x constant, then the pressure diminishes with increase in the value of y—*i.e.* it diminishes as the hand is moved away from the shoulder.

Centre of Gravity.—Every material body consists of a collection of an infinite number of particles, on every one of which gravity exerts a force vertically downward, so that the body as a whole is acted upon by an infinite number of small, like, parallel forces. The resultant of all these forces is their sum, and is equivalent to the total weight of the body—*i.e.* the total force with which the body is attracted by the earth.

A body can only be balanced on a point about which the algebraic sum of the moments of all the forces of attraction on the constituent particles is zero. It is the point through which the line of action (a vertical line) of the resultant of all the forces of attraction must pass, since the moment of the resultant about that point will then be zero. This point is called the *centre of gravity* of the body. The centre of gravity may therefore be defined as *the point at which the whole weight of a body acts in whatever position the body may be.* The centre of gravity of a symmetrical body must necessarily be its centre of symmetry. Thus that of a uniform bar is its middle point—the sum of all the moments of the forces due to gravity on one side of this point being exactly equal and opposite in sign to those on the other side, the algebraic sum of the moments about the centre of symmetry will therefore be zero. Similarly, the centre of gravity of a circular ring or circular area is its centre, and so on for all symmetrical bodies. It follows that, if a body possesses a *line* of symmetry, the c.g. must be situated on that line. In any triangle, ABC for example, the line AD, drawn from the apex A to the middle point of the base BC, is a line of symmetry. The c.g. must therefore be situated on AD. By drawing another such line, CE, we again argue that the c.g. must also be situated on this line. Hence the c.g. of the triangle must be the point of intersection G of these two lines of symmetry.

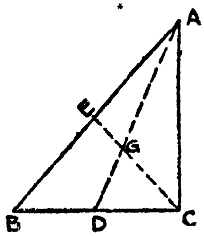


FIG. 27.

The c.g. of a body or system of particles can be found mathematically, by finding the position of the point about which the algebraic sum of the moments of the particles which constitute the body is zero. This can, however, be done more easily by an application of the following proposition. The moment of the resultant—*i.e.* the moment of the total weight (supposed to be acting at the centre of gravity)—about *any* point or line must be equal to the algebraic sum of the moments of all the particles about this point or line.[1]

This is illustrated in the following couple of examples:

(1) A telescope consists of three uniform tubes, one within the other; they are 10, 9, and 8 inches in length, and weigh 9, 8, and 7 ounces respectively. Find the position of the c.g. when the tubes are drawn out at full length.

Let AB, BC, CD represent the three tubes. The tubes being uniform, the c.g. of each acts at the middle point of each. The system is therefore equivalent to three particles of

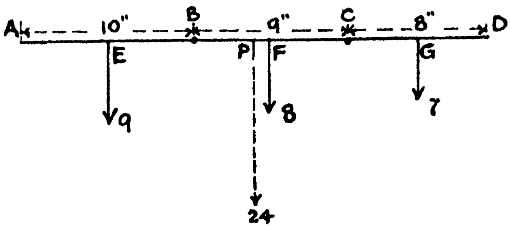


FIG. 28.

weights 9, 8, and 7, acting at E, F, and G. The resultant is a weight of 24 acting at some point P, the position of which has to be found. Take moments about A. Let x be the distance of P from A. The sum of the moments of the tubes about A is:

$$\begin{aligned}&(9\times 5)+8(10+4\tfrac{1}{2})+7(19+4)\\&=45+116+161\\&=322.\end{aligned}$$

[1] This proposition is evident in the light of the preceding remarks. It can, however, be proved formally.

And this must equal the moment of the resultant about A.

$$\therefore \quad 24x = 322$$

$$\therefore \quad x = \frac{322}{24} = 13\tfrac{5}{12}.$$

Therefore the centre of gravity is a point distant $13\frac{5}{12}$ inches from A, or $\frac{1}{12}$ inch from the centre of the whole, on the side nearest the longest tube.

(2) Three equal weights are placed at the corners of a piece of cardboard cut into the form of an equilateral triangle. Assuming that the cardboard itself is weightless, find the point about which the system will balance, *i.e.* find the c.g.

Let w be the weight at each corner. From the apex A draw AD perpendicular to BC (Fig. 29). Since the triangle is equilateral, D will be the mid-point of BC. Let $\bar{x}$ be the distance of

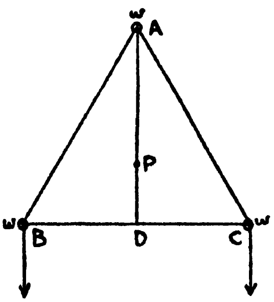


FIG. 29.

the c.g. from AD. Taking moments about AD: $w \cdot BD - w \cdot DC = 3w \cdot \bar{x}$. (The weight at A being on AD has no moment about AD; the moment of the weight at C about AD is negative, producing a tendency to a clockwise rotation.) Since $BD = DC \therefore \bar{x} = 0$. Hence the c.g. is a point on AD. Next, let $\bar{y}$ be the distance of the c.g. from BC. Taking moments about BC: $w \cdot AD = 3w \cdot \bar{y}$. (The weights at B and C have no moments about BC.)

$$\therefore \quad \bar{y} = \frac{AD}{3}$$

Hence the c.g. is the point P situated on AD, and distant $\frac{1}{3}$ AD from BC.

The c.g. of a non-symmetrical body may be found by experiment. Suspend the body from any fixed point A in it, and let it assume a position of equilibrium [Fig. 30 (*a*)]. Since the body is at rest under two forces—that of its own weight and that at the point of suspension—these two forces must be equal and opposite. Hence the c.g. must lie in a vertical line drawn through A. Now release the body and suspend it from some other point B [Fig. 30 (*b*)]. As before, the c.g. must lie in the vertical line drawn through B. Hence the c.g. is the point of intersection G of the two lines AG and BG.

A heavy body suspended at a fixed point is evidently in equilibrium, provided the point of

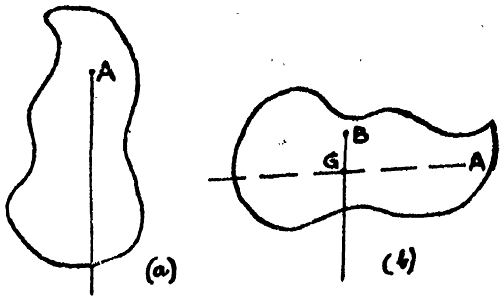


FIG. 30.

suspension and the c.g. are in one and the same vertical straight line. Three possible cases arise:

(1) The c.g. may be below the point of suspension.

(2) The c.g. may be above the point of suspension.

(3) The c.g. may coincide with the point of suspension.

In the first case, the body, if slightly displaced from its position of rest, will of its own accord turn back to its original position when released. The equilibrium, in such a case, is said to be *stable*. In the second case the body, if slightly displaced from its position of rest, will not return to its original position, but will turn still further away from this position. The equilibrium, in such a case, is said to be *unstable*. In the third case the body, when slightly displaced, remains at rest in its *new* position. The equilibrium is then said to be *neutral*.

The terms stable, unstable, and neutral equilibrium, with the meanings just attached to them, are applicable not merely to a body fixed at one point, but to any body at rest under a number of forces. If, for example, a body is placed on a smooth horizontal plane, the condition for stable equilibrium is that a vertical line dropped from the c.g. must fall within the base area. If it does not do so, the body is "top-heavy" and will fall over. By the base area, however, is meant, not necessarily the actual area in contact with the plane, but the area enclosed by a string drawn *tightly* round the body where it meets the plane; this latter area may be sometimes greater than the actual area of the base (Fig. 31). A table in its usual position is an instance of stable equilibrium; if slightly tilted and "let go" its own weight will turn it back to its original position. A cone balanced on its vertex is in unstable equilibrium

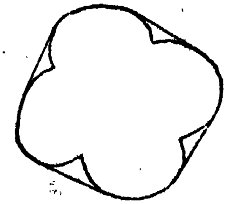


FIG. 31.

—the slightest touch will cause it to topple over. A ball at rest on a horizontal plane is an example of neutral equilibrium—if slightly displaced it remains at rest in its new position.

General Conditions of Equilibrium.—We are now in a position to understand what must be the conditions which result in the equilibrium of a body, when acted upon by any number of forces in one plane. In the first place, the resultant of all the forces must be zero. But this alone is not sufficient. In Fig. 24 we have two equal unlike forces acting on a body; their resultant is zero, but they constitute a couple exerting a turning motion on the body. Hence the second condition required is that the forces must not constitute one or more couples. This condition will be satisfied if the algebraic sum of the moments of all the forces about any point in their plane is zero.

A few simple illustrations should suffice.

(1) A body is in equilibrium if supported at its c.g. The whole weight of the body acts at its c.g. The point of support bears this weight and *reacts* with an exactly equal and opposite force. The resultant of the weight and this reaction is therefore zero, and satisfies the first condition. Further, the moment of the weight about the c.g. and that of the reaction about the same point are each zero. This satisfies the second condition, and hence the body must be in equilibrium if supported at its c.g.

(2) One end of a uniform rod weighing 1 lb. is attached to a hinge; the other end is supported by a string. If the rod and string are inclined at the same angle of 60° to the horizontal, find the force at the hinge and the tension in the string.

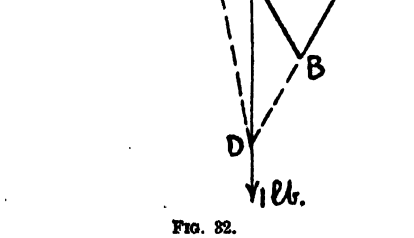


FIG. 32.

Let AB represent the rod, M its middle point, A the hinge, and BC the string (Fig. 32). The rod is in equilibrium under its own weight of 1 lb. acting vertically downwards, the tension T in the string acting in direction B C, and an unknown force F at the hinge. These three forces must meet at a point (Principle of Triangle of Forces, p. 557). Hence produce CB to meet the vertical through M at D. Join DA; then DA is the line of action of the force at the hinge A. We can thus solve the problem graphically, by drawing a triangle whose sides are parallel to the directions of the three forces. To solve it algebraically, however, we apply the preceding conditions of equilibrium.

First, to find the resultant of all the forces, resolve the forces into components in two directions at right angles, the most suitable being in this case the horizontal and vertical directions. T resolves into a horizontal component T cos 60°, and a vertical component T sin 60°.

The weight of 1 lb. being vertical does not provide a horizontal component. The force F at the hinge being unknown in both magnitude and direction, we *assume* that it is the resultant of a horizontal force F_x, and a vertical force F_y.

Now, since the resultant of *all* the forces must be zero, it follows that the algebraic sum of all the horizontal components of these forces must be zero, and *also* the algebraic sum of all their vertical components must be zero. Hence we obtain the following two equations:

$$F_x + T\cos 60° = 0 \quad . \quad . \quad . \quad (a)$$
$$F_y - 1 + T\sin 60° = 0 \quad . \quad . \quad (b)$$

(The force of 1 lb. is considered negative, in accordance with the usual convention of calling an upward direction positive and a downward one negative.)

According to the second condition of equilibrium, the sum of the moments of all the forces, about some point or line in their plane, must be zero. A convenient point to choose is the point A itself, for then the moment of F about A is zero and need not be considered. The moment of the weight of 1 lb. about A is $1 \times AP$, and is negative (AP is the perpendicular distance of A from the line of action of the force). The moment of T about A is $T \times AQ$, and is positive (AQ is perpendicular to BC). We therefore get the following equation:

$$-1 \times AP + T.AQ = 0.$$

If AB, the length of the rod is l, then $AM = \frac{l}{2}$ and $AP = \frac{l}{2}\cos 60°$.

Since $\underline{|ABC}$ must be 60° and $\underline{|AQB}$ is 90°, the $\underline{|BAQ}$ is 30°.

Hence $AQ = l\cos 30°$.

The last equation consequently becomes

$$-1 \times \frac{l}{2}\cos 60° + T \quad l\cos 30° = 0 \qquad (c)$$

Now $\cos 60° = \frac{1}{2}$; $\cos 30° = \frac{\sqrt{3}}{2}$; $\sin 60° = \frac{\sqrt{3}}{2}$

From (c) $T \cdot l \cdot \frac{\sqrt{3}}{2} = \frac{l}{2} \cdot \frac{1}{2}$.

$\therefore T = \frac{1}{2\sqrt{3}} = \frac{\sqrt{3}}{6} = \frac{1 \cdot 73}{6} = \cdot 29$ lb. weight nearly, which gives the required tension in the string.

Substituting this value of T in (a) we obtain $F_x = -\frac{\sqrt{3}}{6 \times 2} = -\frac{\sqrt{3}}{12}$. The horizontal component of F thus acts in a negative direction, as illustrated. Substituting for T in (b):

$$F_y = 1 - \frac{\sqrt{3}}{6} \cdot \frac{\sqrt{3}}{2} = \frac{3}{4},$$

and acts in an upward direction.

The resultant F must therefore act as shown in the figure, and its value

$$F = \sqrt{F_x^2 + F_y^2} = \sqrt{\frac{3}{144} + \frac{9}{16}}$$
$$\frac{\sqrt{84}}{144} = \cdot 76 \text{ lb. weight},$$

which is the force acting at the hinge.

Law 2.—"*The rate of change of momentum is proportional to the impressed force, and takes place in the direction of the straight line in which the force acts.*"

"Momentum" means the product of a mass into the velocity with which it is moving, so that if M represents the mass of a body and V its velocity, the momentum of the body is MV. At once the question arises: "What is meant by the *mass* of a body?"

Mass and Weight.—Mass, Time, and Length are three fundamental conceptions at which we arrive naturally, and which we use as a basis for further reasoning. How the human mind achieves these conceptions is a psychological problem which does not concern us here. Being a fundamental conception, the term "mass" does not admit of definition, since the definition of an idea involves an explanation in terms of simpler, more fundamental ideas. All we can say is that the idea or conception of mass always forms part of our conception of any material body. Our conception of a brick, for example, is a very complex combination of many factors—it includes the dimensions of the brick, its feel of hardness, its structure, its colour, its *mass*, &c. And this idea of mass is a common factor in our conceptions of all material bodies—in other words, "every material body possesses mass."

In many text-books, "mass" is defined as "the quantity of matter in a body," but that, in the writer's opinion, is less clear than the term "mass" which it attempts to explain.

We unconsciously compare the masses of bodies by their weights. A lump of iron is said to be more massive than a feather—it possesses a greater mass. For this reason one is apt to confuse mass with weight, although they represent two quite distinct ideas. The weight of a body —its feel of heaviness—is the perception of the force with which the earth attracts the body, whereas its mass is quite independent of the attraction of the earth. If we could remove a body sufficiently far from the earth, its weight would diminish and ultimately become zero, but its mass would remain unchanged. "Weight" is therefore a force—the force with which the earth attracts, whereas mass is the ultimate cause of the earth's attraction. The smaller the mass of a body, the smaller is the resultant attractive force of the earth upon it, and if we could conceive the existence of a body possessing no mass at all, then we should find that the earth's attraction upon it would be zero.

The Second Law expressed as an Equation.—We have already seen (Newton's First Law) that the effect of a force on a body is to produce a change in its velocity, and in so far as every material body possesses mass, the effect of a force must be to produce a change of momentum. Putting this statement into mathematical form, if M is the mass of a body, V_1 its original velocity (before the application of a force), V_2 its final velocity, then the effect of the force is to change the momentum from MV_1 to MV_2, a change equal to $M(V_2 - V_1)$. Further, if τ is a small interval of time during which this change of momentum has taken place, then the *rate* of change of velocity $= \frac{V_2 - V_1}{\tau} =$ the acceleration,

and the *rate* of change of momentum $= \frac{M(V_2 - V_1)}{\tau}$ $= M \times$ acceleration $= M.f$, if "f" represents the acceleration.

Now Newton's Second Law states that this rate of change of momentum is directly proportional to the acting (or impressed) force, so that the greater the force the greater is the rate at which the momentum changes. We know from practical experience that this is so, that in estimating the magnitude of a force we take into account not only the rate at which the velocity changes under the influence of that force, but also the mass of the body acted upon. The Second Law is therefore expressed in mathematical terms by $F \propto Mf$ (F representing the force, and the symbol $\propto$ being used to indicate "varies as"). This last expression is equivalent to, $F = k.M.f$, in which k represents a constant quantity, so that the ratio,[1] $\frac{F}{M.f} = k$. The equation $F = k.M.f$ is of the utmost importance, and must be considered in greater detail.

The Unit of Force.—M, the mass of a body, is

[1] See *ratio* in section on Arithmetic and Algebra, p. 464.

expressed in terms of its weight, so that a body weighing 3 lbs. is said to possess a mass of 3. At the same time, the reader must bear in mind that the "weight" of 3 lbs. is the force with which the earth attracts a "mass" of 3, and that the two ideas, weight and mass, must be clearly distinguished. The unit of mass is thus a pound. "f," the acceleration, is measured in feet per second per second, and in the case of gravity it is equal to 32·2, or roughly, 32. Now, if F is the force with which the earth attracts unit mass, then $F = k \times 1 \times 32$, and the value of F is still unknown until the value of k has been found. The value of k cannot be found, but the difficulty is ingeniously overcome by a *suitable choice of the unit of force*. The unit of force is so chosen that, when unit force acts on unit mass it produces unit acceleration. What do we get then? In such a case, since $F=1$ when $M=1$ and $f=1$, then by substituting in the equation $F=k.M.f$, we get $1=k \times 1 \times 1$; or with the unit of force chosen in the manner just described $k=1$, and the mathematical expression of the second law becomes

$F=M.f$. . . . . *Equation* (12).

We can now resume the attempt to find the force F with which the earth attracts unit mass. By means of equation (12):

$F=1 \times g=32$ units of force approximately.

It follows, therefore, that the unit of force is $\frac{1}{32}$nd part of the force exerted by the earth on a mass of 16 ozs. or it is equal to the force with which the earth attracts a mass of $\frac{1}{2}$ oz. The unit of force is thus equivalent to a $\frac{1}{2}$ oz. *weight*, and is termed a *poundal*. This is on the assumption that $g=32$, and for practical purposes it is sufficiently accurate, and will be the value adopted in the following pages. A weight of 1 lb. is thus equivalent to a force of 32 poundals. A clear grasp of the distinction between mass and weight now becomes imperative for the purpose of an intelligent application of equation (12), in which *the force is expressed in terms of poundals and the* **mass in terms of pounds.** A weight of 3 lb. would therefore have to be designated as a force of (not 3, but) 96 poundals, in order that the two sides of equation (12) should be equivalent; thus $96=3 \times 32$.

The poundal is the English unit of force, as it is based on the English system of units in which the unit of mass is a pound and the unit of length a foot. In the French system the unit of mass is a gramme, and the unit of length a centimetre. Also, the acceleration of a falling body is 981 cm. per sec. per sec. Hence the force F that acts on a mass of 1 gm. is given by

$F=1 \times 981=981$ units of force.

In the French system of units therefore, the unit of force is the $\frac{1}{981}$st part of a gramme weight, and is called a *dyne*. In calculations the two systems of units, English and French, must be kept quite distinct; one must not, for example, speak of a velocity of so many *feet* per second in connection with a mass of so many grammes. The English system of units is called the "Foot-Pound-Second" system (abbreviated to F.P.S. system), the foot, the pound, and the second being the units of length, mass, and time respectively. The French system of units is, for similar reasons, called the "Centimetre-Gramme-Second" system (abbreviated to C.G.S. system).

Application of Equation (12).—Equation (12), the equation of *linear* motion, or motion of translation as it is frequently called to distinguish it from one of rotation, is probably the most important equation in the whole realm of science. Strictly, it applies only to a particle, but it is also applicable to an extended rigid body, on the assumption that the centre of gravity of the body moves as if it contained the whole mass and all the external forces were applied at this point, parallel to their original directions. This assumption is a deduction of D'Alembert's principle, which will be discussed under Newton's Third Law.

In a short article such as this one cannot do more than barely indicate the application of the equation $F=M.f$ to mechanical problems by means of a few examples.

Example 1.—A mass of 12 lb. is acted upon by a constant force which, in 5 seconds, produces a velocity of 15 feet per second. What is the magnitude of the force if the mass was initially at rest?

We know the mass, and we know the effect of the force; this should enable us to find the force F, by applying the formula $F=M.f$. First apply equation (8) viz.:

$$v=u+f.t$$

$$\text{then} \quad 15=0+f.5$$

$$\therefore \quad f=3 \text{ ft. per sec. per sec.}$$

$$\therefore F=M.f=12 \times 3=36 \text{ poundals or } 1\tfrac{1}{8} \text{ lb. wt.}$$

Example 2.—A truck weighing 15 tons, initially at rest, is pulled by a horse with a constant force equal to the weight of 1 cwt. in the direction of the rails. How far will it move in 5 minutes?

Remembering that, for the purpose of applying the formula $F=M.f$, the mass must be expressed in pounds and the force in poundals, we proceed thus: 15 tons$=15 \times 2240$ lb.

A force equal to the weight of 1 cwt. $=$ a force of 112×32 poundals.

$$\therefore \quad 112 \times 32=15 \times 2240 \times f.$$

$$\therefore \quad \text{The acceleration } f=\frac{8}{75} \text{ ft. per sec. per. sec.}$$

Now apply equation (9), viz. $s=ut+\frac{1}{2}ft^2$.

$$\text{Since} \quad t=5 \times 60=300 \text{ secs.}$$

$$\therefore \quad s=0+\frac{1}{2} \times \frac{8}{75} \times \frac{(300)^2}{1}=4800 \text{ ft.}$$

which is the distance the truck will move.

Example 3.—An engine weighing 20 tons pulls a train weighing 80 tons, the resistance due to friction being 20 lbs. per ton. What must be the force exerted by the engine if, at the end of the first mile from the start, the speed is 30 miles per hour ?

Total mass = 100 tons = 100 ×2240 lb.

30 miles per hour = 44 ft. per sec., and 1 mile = 5280 ft.

Applying equation (10), $v^2 = u^2 + 2f.5280$

$$(44)^2 = 0 + 2.f \,.\, 5280$$

$$\therefore \quad f = \tfrac{11}{60} \text{ ft. per sec. per sec.}$$

The force F′ acting on a mass of 100 tons, and producing this acceleration supposing there were no frictional resistance is $F' = M.f.$

$\therefore \quad F' = 100 \times 2240 \times \frac{11}{60}$ poundals $= 1283\frac{1}{3}$ lb. wt.

The resistance = a force of $100 \times 20 = 2000$ lb. weight.

∴ The total force F that must be exerted by the engine = $3,283\frac{1}{3}$ lb. weight.

Example 4.—A weight of 10 lb. falls, from rest, a vertical distance of 16 feet on to a heap of sand which it penetrates a distance of 1 foot. Find the average force of resistance of the sand.

The velocity v with which the weight strikes the heap is given by

$$\begin{aligned} v^2 &= u^2 + 2gs \\ &= 0 + 2 \times 32 \times 16 \\ \therefore \quad v &= 32 \text{ feet per sec.} \end{aligned}$$

During the passage through 1 foot of sand this velocity is entirely destroyed. Hence the final retardation f' is given by

$$\begin{aligned} v^2 &= u^2 - 2f's \\ \text{or} \quad 0 &= 32^2 - 2f' \times 1 \\ \therefore \quad f' &= 512. \end{aligned}$$

But the actual retardation "f" which the sand produces must be greater than this, since during the time of fall through the sand gravity is still acting and f' is the resultant of "f" less g.

$$\therefore \quad f' = f - g \text{ or } f = f' + g$$
$$\therefore \quad f = 512 + 32 = 544.$$

∴ The force of resistance $F = 10 \times 544$ poundals $= 170$ lb. weight.

Example 5.—A bullet weighing 100 grammes is discharged from a rifle, whose barrel is 100 cms. long, with a velocity of 1000 cms. a second. What is the average force exerted on the bullet during the explosion ?

The bullet starts from rest and, while travelling the length of the barrel under the influence of the explosion, it acquires a velocity of 1000 cms. per sec. Hence the acceleration produced by the explosion is given by

$$v^2 = u^2 + 2fs$$
$$\therefore \quad (1000)^2 = 0 + 2.f. \times 100$$
$$\therefore \quad f = 5000 \text{ cms. per sec. per sec.}$$

Hence the force of the explosion $F = 100 \times 5000 = 500,000$ dynes.

Example 6.—A lift *starts* moving downwards with an acceleration of 10 feet per sec. per sec. What is the pressure exerted on the floor of the lift by a man weighing 10 stone ?

Let the pressure be equal to a force of P lbs. This is the force with which the floor reacts in an upward direction (see Law 3). The resultant force therefore equals $(140-P)$ lbs. $= (140-P) \times 32$ poundals. And this must equal the mass moved, multiplied by the acceleration f (Equation 12).

$$\therefore \quad (140-P) \times 32 = 140f.$$

Now consider the following cases :

(i) When the lift is at rest, f is zero and ∴ $(140-P) \times 32 = 0$ and $P = 140$ lbs.

(ii) When the lift is moving with its maximum velocity, the acceleration is again zero and P is again equal to 140.

In both these cases therefore the pressure on the floor is equal to the man's weight.

(iii) When the lift starts, the acceleration is 10 and ∴ $(140-P) \times 32 = 140 \times 10$

$$\therefore \quad P = 140\left(\frac{32-10}{32}\right) = \frac{22}{32} \text{ of } 140 \text{ lbs.}$$

which is *less* than his weight.

(iv) As the lift is stopping the acceleration becomes negative, $-f$ suppose, and

$$\therefore \quad (140-P)32 = -f \times 140$$

$$\therefore \quad P = \frac{32+f}{32} \text{ of } 140 \text{ lbs.}$$

which is *greater* than his weight.

(iii) and (iv) account for the sensations experienced in a lift at starting and stopping.

Example 7.—A locomotive engine weighing 10 tons passes round a curve 500 feet in radius with a speed of 10 miles an hour ; what force tending towards the centre of the curve is exerted between the rails and flanges of the wheels ?

$$10 \text{ miles an hour} = \frac{44}{3} \text{ ft. a second.}$$

The acceleration towards the centre of the curve is $\dfrac{\left(\frac{44}{3}\right)^2}{500}$ (see equation 7). The mass $= 10 \times 2,240$ lbs.

Hence the force $= 10 \times 2,240 \times \dfrac{44^2}{3^2 \times 550}$ poundals $= 301\frac{7}{45}$ lbs.

Example 8.—A bullet is projected with a velocity of 600 feet a second, at an angle of 30° with the horizontal. Find (1) the greatest height to which the bullet rises ; (2) the time of flight ; and (3) the horizontal range.

(*Note*.—The path described by a projectile is called its *trajectory*, and is always a parabola.)

The "time of flight" is the time that elapses before the projectile reaches a point in the

same horizontal plane as the point of projection, or the time taken to travel the horizontal range.

The given velocity can be resolved into:

(i) A velocity of 600 cos $30° = 600 \times \frac{\sqrt{3}}{2}$ in a horizontal direction, together with (ii) a velocity of 600 sin $30° = 300$ in a vertical direction.

Omitting air resistance, the only force acting on the bullet during its flight is a vertical one, producing an acceleration g downward. As the change in momentum takes place in the direction of the impressed force (see latter half of Law 2), it follows that the only change in velocity will be in the vertical direction, and the horizontal velocity of $600 \times \frac{\sqrt{3}}{2}$ feet per second remains unchanged throughout the motion.

If h is the greatest height attained, then h is the distance which the bullet, starting with a vertical velocity of 300 and moving with acceleration $-g$ (or -32), travels before its vertical velocity becomes zero, since the bullet will continue rising until its vertical velocity is zero.

Hence, applying equation (10),

$$0^2 = (300)^2 - 2 \times 32 \times h$$

$$\therefore \quad h = \frac{300 \times 300}{2 \times 32} = 1,606\tfrac{1}{4} \text{ ft.}$$

If t is the time of flight, then in "t" seconds the total vertical distance described is zero, since at the end of that time the bullet is assumed to have reached the same horizontal plane as that in which the point of projection is situated:

$$\therefore \quad 0 = 300t - \tfrac{1}{2} \cdot 32t^2 \text{ by equation (9)}$$

$$\therefore \quad 16t = 300 \text{ and } t = 18\tfrac{3}{4} \text{ secs.}$$

Since the bullet travels for $18\frac{3}{4}$ seconds with a constant horizontal velocity of $300\sqrt{3}$ feet per second, the horizontal range must be $300\sqrt{3} \times 18\frac{3}{4} = 9,742 \cdot 8$ feet, approximately.

Work and Energy.—To perform work a force must be utilised, and the scientific measure of the amount of work performed by a force F is the product of F into the distance s through which the point of application of the force has moved, *in the direction of* F. If W represents the work done then $W = Fs$. Suppose, for example, a body of mass 2 lb. slides down a smooth, inclined plane AB of length 4 feet, the point A being 1 foot vertically above B (Fig. 33). The work done by gravity, in pulling the weight down the incline, is then measured by the product 64 poundals into the distance moved by the body in the *direction of the force, i.e.* the vertical distance AC, which is 1 foot. The work done is thus, 64 poundals × 1 foot = 64 units of work. Or, if the actual distance AB moved through by the body is taken as the distance s, then the force to be taken into account is not the actual force of 64 poundals, but the fraction of this force which acts in the direction AB. The value of this is 64 sin $\underline{|ABC}$ $= 64 \times \frac{1}{4} = 16$, and the work done is 16 poundals × 4 feet = 64 units of work, as before.

The natural unit of work is a force of 1 poundal

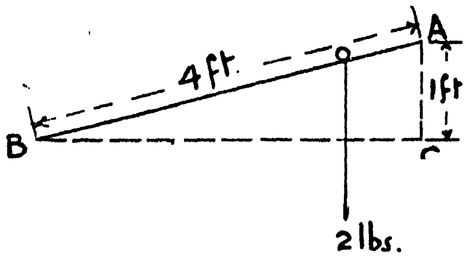


FIG. 33.

exerted through a distance of 1 foot, in its own direction. This unit is called a *foot-poundal.* In actual practice, however, the unit adopted is a *foot-pound,* which is the work done by a force equal to the weight of 1 lb. exerted through a distance of 1 foot. A foot-pound is thus equal to g foot-poundals = 32 foot-poundals approximately.

In c.g.s. units, the unit of work is that of a force of 1 dyne exerted through a distance of 1 cm., in its own direction. This unit is called an *erg.*

We know that the effect of a force is to produce a change in the velocity of a body; hence the work done by a force can be expressed in terms of the change in velocity caused by it.

Since $F = M.f$ $\quad\quad \therefore F.s = M.f.s.$

And if the body is moving with uniform velocity u before the application of the force, and as a result of the action of the force through a distance s, the final velocity is v, then we know that

$$v^2 = u^2 + 2fs$$

$$\therefore \quad fs = \frac{v^2 - u^2}{2}$$

$\therefore F.s = M.f.s. = \frac{1}{2}M(v^2 - u^2)$ . . . *Equation* (13), an important expression which gives the value of the work performed by a force, in terms of the mass, and the initial and final velocities of the body. It must be borne in mind that the argument, and the resulting equation (13), has reference only to linear motion and does not apply to bodies having any motion of rotation.

Half the product of the mass of a body into the square of its velocity is termed the *Kinetic Energy* of the body. In the last equation, therefore, $\frac{1}{2}Mu^2$ represents the kinetic energy of the body before the application of the force, and $\frac{1}{2}Mv^2$ the kinetic energy after the force had been acting through a distance s. The expression $\frac{1}{2}M(v^2 - u^2)$ thus represents the *gain*

in kinetic energy, and equation (13) becomes in words:

Work done by a force = gain in kinetic energy of the body acted upon.

Conversely, if the motion of a body is opposed by a force, its velocity will diminish and there will be a loss in the kinetic energy of the body, a loss which will be exactly equal to the work done by the body against the opposing force. Kinetic energy is therefore defined as the "ability to do work," this ability being a direct result of the motion of the body. Or, kinetic energy may be considered as the form in which the work done on a body is stored. There is a cycle. Work is done on a body and, as a result, the body is endowed with kinetic energy which, properly utilised, can be made to do an amount of work exactly equal to that previously expended on the body.

A body may possess energy, that is the capacity to do work, in a form other than kinetic. A bent spring possesses energy, viz. the work it can do in the process of regaining its natural shape; a weight at rest on the table possesses energy, since if the support of the table be removed, it will fall and in the process of falling it is capable of doing work; compressed air possesses energy, viz. the work it is capable of performing in the process of expanding. In all these instances the energy is not a result of the motion of the body, but the result of work that had been previously performed upon it—the energy possessed by the spring in its bent form is due to the work previously performed on it in the process of bending it, that of the weight at rest on the table is the result of work performed on it in lifting it from the floor on to the table, and that of the compressed air is the result of work done previously in compressing the air. This form of energy—energy possessed by a body although *at rest*—is called *Potential Energy*. A body may thus possess either kinetic or potential energy (or both), but whether kinetic or potential or both, the total energy is exactly equal to the work previously performed upon the body. The potential energy of a body of mass M raised to a height h is Mgh foot-poundals, that being the work performed on the body in raising it through a height of h feet. We constantly have cases arising of potential energy changing to kinetic and *vice versa*. Let us follow such a change in a concrete case. Suppose a weight of 10 lb. falling through a height of 100 feet to the surface of the Earth. At the commencement of its fall its energy is entirely potential and is equal to 1,000g foot-poundals. At the end of its fall, when it reaches the ground, its energy is entirely kinetic and is equal to $\frac{1}{2}Mv^2$.

Now $v^2 = 2g.s = 2g. \times 10 = 20g$,

$\therefore \quad \frac{1}{2}Mv^2 = \frac{1}{2} \times 100 \times 20g = 1{,}000g$ foot-poundals.

The kinetic energy at the end of the fall is therefore equal to the potential energy at the commencement. Let us now consider some intermediate position, such as that attained after a fall of 20 feet. The body, in such a position, possesses kinetic energy due to a fall of 20 feet, and potential energy due to the fact that it is still 80 feet above the ground. After a fall of 20 feet, $v^2 = 2 \times g \times 20 = 40g$, and the kinetic energy is therefore $\frac{1}{2} \times 10 \times 40g = 200g$. The potential energy at a point 80 feet above ground is 800g. The sum-total of the energy is therefore again 1,000g. Similarly the reader may prove for himself that at every point in the course of the fall the *sum-total of the energy possessed by the body remains constant*. In other words, a change of energy from one form to another is unaccompanied by any loss. This is a most important scientific principle known as the *Principle of Conservation of Energy*. It is sometimes expressed by the statement that "*Energy is indestructible*." The recognition of forms of energy other than mechanical, such as chemical energy, electrical energy, heat energy, &c., and the application of the principle of conservation of energy to these, has led to most important advances in every branch of science.

Moment of Inertia.—In the preceding pages we have considered the kinetic energy of a body whose motion is purely linear. We must now consider what the kinetic energy is of a body whose motion is purely one of rotation about some point or axis, either within or without the body.

Let the figure (Fig. 34) represent the section (in the plane of the paper) of a body rotating

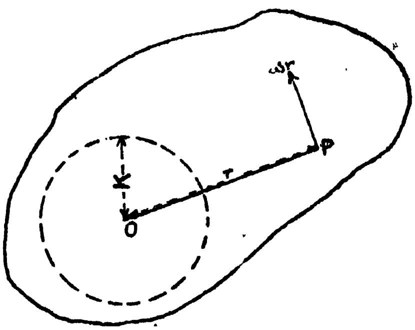


FIG. 34.

about an axis through O perpendicular to the plane of the paper. The body consists of a large number of particles. Consider any one particle P, distant r from the axis. Let w be the angular velocity of the body about the axis—w naturally has the same value for all the particles. The linear velocity of the particle P is wr in a direction at right angles to OP. If m is the mass of the particle its kinetic energy is $\frac{1}{2}m(wr)^2 = \frac{1}{2}mw^2r^2$. And the kinetic energy of the whole body is the summation of this expression for *all* the particles contained in the

body. This summation is written $\Sigma(\frac{1}{2}mw^2r^2)$. Now w is the same for each particle, "m" will be the same for each particle if the body is of uniform density, but will vary if the density varies from point to point, and r will vary with the positions of the particles. Denote the variations of m and r by m_1r_1, m_2r_2, &c. Then $\Sigma(\frac{1}{2}mw^2r^2)$

$$=\tfrac{1}{2}m_1w^2r_1^2+\tfrac{1}{2}m_2w^2r_2^2+\tfrac{1}{2}m_3w^2r_3^2+\ .\ .\ .\ \text{\&c.}$$
$$=\tfrac{1}{2}w^2(m_1r_1^2+m_2r_2^2+m_3r_3^2+\ .\ .\ .\ \text{\&c.})$$

The factor $(m_1r_1^2+m_2r_2^2+m_3r_3^2+\ .\ .\ .\ \text{\&c.})$ does not depend on the velocity of rotation, but only on the masses of the particles and their distances from the axis of rotation. It has, therefore, a constant value for any given body rotating about a given axis, a value equal to MK^2 where M is the total mass of the body and K some length to be determined. The value of K depends on the form of the body and the position of the axis of rotation, and can generally be calculated by means of the Integral Calculus. I shall not attempt it here, but a table of the values of K^2 is given overleaf for certain common forms, the axis of rotation being a line passing through the *c.g.* of the body. It is to be noted that K^2 is a sort of average of a number of lengths, r_1, r_2, &c., each of which is squared. If with centre O and radius K, a circle be described (Fig. 34), and all the particles in the plane of the paper supposed situated on that circle, then the kinetic energy of such a system would be

$$\tfrac{1}{2}w^2K^2(m_1+m_2+m_3+\ .\ .\ .\ )$$

which equals $\frac{1}{2}w^2K^2M$, which is exactly equivalent to the kinetic energy of the actual system under consideration. K is thus the distance from the given axis, at which all the particles of the body may be *supposed* situated, and for that reason K is called the *radius of gyration* of the body about the given axis. The expression MK^2 is termed the *moment of inertia* of the body about the given axis, and is usually denoted by the letter I.

Hence the kinetic energy of a rotating body $=\frac{1}{2}MK^2w^2=\frac{1}{2}Iw^2$. This expression is very similar to the expression $\frac{1}{2}Mv^2$ (which denotes the kinetic energy of a body possessing a linear motion only), I, the moment of inertia about the given axis replacing M, and w, the angular velocity, being substituted for v, the linear velocity.

The moment of inertia of a body of mass M about an axis which does not pass through the centre of gravity but is situated a known distance d from it, may be found by means of the following equation:

The required Moment of Inertia = Moment of Inertia about a parallel axis through the centre of gravity $+Md^2$ . . . *Equation* (14).

As an example, let us find the kinetic energy of a thin rod 2 feet in length, and weighing $\frac{1}{4}$ lb., when it is rotating about an axis at its end perpendicular to its length, the rotation being a uniform one of 10 revolutions a minute.

$$\text{Kinetic energy}=\frac{1}{2}Iw^2.$$

A complete revolution being an angle of 2π, $w=\frac{20\pi}{60}=\frac{\pi}{3}$; K^2 about an axis through the centre of gravity parallel to the given axis $=\frac{l^2}{12}=\frac{4}{12}=\frac{1}{3}$ (see Table overleaf). ∴ Moment of inertia about an axis through the centre of gravity $=MK^2=\frac{1}{4}\times\frac{1}{3}=\frac{1}{12}$.

Distance "d" of given axis from the centre of gravity is 1 foot.

∴ Equation (14) gives

$$I=\tfrac{1}{12}+Md^2=\tfrac{1}{12}+\tfrac{1}{4}(1)^2=\tfrac{1}{3}.$$

∴ Kinetic energy of the rod

$$=\tfrac{1}{2}\ Iw^2=\tfrac{1}{2}\times\tfrac{1}{3}\times\left(\frac{\pi}{3}\right)^2=\tfrac{484}{2646}\ \text{foot-poundals.}$$

Law for Motion of Rotation.—It has been pointed out that the expression for the Kinetic Energy of a rotating body is very similar to the one expressing the Kinetic Energy of a body having linear motion. This is true for all expressions dealing with motions of rotation—I and w have but to be substituted in the analogous expression for motion of translation in order to obtain the expression appropriate to the motion of rotation. Thus, the expression for angular momentum about a given axis is Iw, which is very similar to the expression Mv for linear momentum. And if the angular momentum changes in time t from Iw to Iw' then the rate of change of angular momentum $=\frac{I(w-w')}{t}=I\alpha$ where α represents the angular acceleration.

If one or more external forces, acting on a body, produce a rotation only about a certain axis, the effect of those forces does not depend solely on their magnitude, as is the case in a motion of translation, but depends also on their distances from the given axis, *i.e.* on their moments. Bearing this in mind, we obtain a law governing rotation which is exactly similar to Newton's Second Law governing motion of translation, viz. *The sum of the moments of the external forces about the axis of rotation varies as the rate of change of the angular momentum of the body about that axis.* Or, if E represent the sum of the moments of the external forces, and α the angular acceleration, then

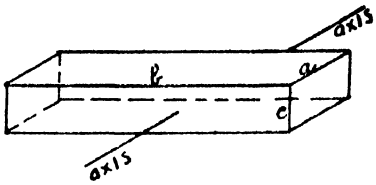
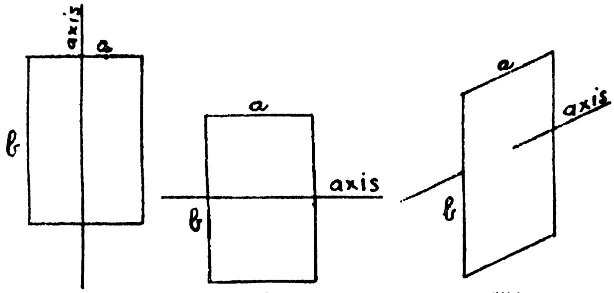
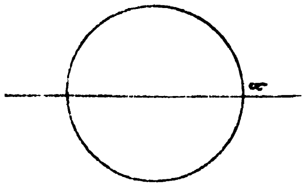
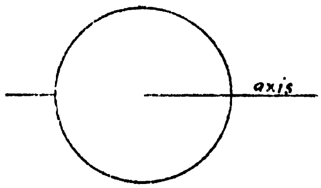
$$E=I\alpha\ .\ .\ .\ \textit{Equation}\ (15),$$

provided that the forces be measured in poundals and the mass in pounds. For example, the uniform brake force necessary to stop, in 2 seconds, a solid wheel (in the form of a disc) 10 inches in diameter, weighing 3 lbs., and making

TABLE FOR K^2,

the axis in each case passing through the centre of gravity of the body.

(Moment of inertia $=MK^2$.)

Thin rod of length l. Axis perpendicular to length of rod		$K^2=\frac{l^2}{12}$
Rectangular bar, sides being of lengths a, b, c. Axis parallel to side a . .		$K^2=\frac{b^2+c^2}{12}$
Thin rectangular plate of sides a, b. (i) Axis parallel to side b. (ii) Axis parallel to side a. (iii) Axis perpendicular to plane of rectangle.	(i.) (ii.) (iii.)	$K^2=\frac{a^2}{12}$ $K^2=\frac{b^2}{12}$ $K^2=\frac{a^2+b^2}{12}$
Thin circular disc of radius r. (i) Axis a diameter.	(i.)	$K^2=\frac{r^2}{4}$
(ii) Axis perpendicular to plane of disc.	(ii.)	$K^2=\frac{r^2}{2}$
Hoop of radius r, axis perpendicular to plane		$K^2=r^2$
Sphere of radius r, axis a diameter		$K^2=\frac{2}{5}r^2$
Solid cylinder of radius r and length l. (i) Axis that of cylinder itself . . . . (ii) Axis perpendicular to axis of cylinder		 $K^2=\frac{r^2}{2}$ $K^2=\frac{r^2}{4}+\frac{l^2}{12}$

5 revolutions a second, the wheel having no motion of translation, would be calculated thus:

$$w = 10\pi$$

the final angular velocity is zero.

$\therefore$ From equation (8′). $0 = 10\pi + a.2$ and $a = -5\pi$.

K^2 for a disc about an axis through the centre, perpendicular to the plane of the disc $= \frac{r^2}{2}$

$$= \left(\frac{5}{12}\right)^2 \Big/ 2 = \frac{25}{288}.$$

$$\therefore \quad I = MK^2 = 3 \times \frac{25}{288} = \frac{75}{288}$$

$\therefore \quad E = Ia = -\frac{5\pi \times 75}{288} = -\frac{375\pi}{288}$ poundals, the negative sign denoting that the force is a retarding one.

If P is the brake force applied at the *rim* of the wheel, then its moment $E = P \cdot \frac{5}{12}$ and $P = \frac{12}{5} \times \frac{375\pi}{288}$ poundals $= 9{\cdot}8$ poundals approximately.

Motion in General.—Motion of translation and motion of rotation have been considered separately, but the most general form of motion is, in practice, one which partakes of both. To such cases the following principles, formally proved in advanced books on the subject, should be applied.

(1) The centre of gravity of a rigid body moves as if it contained the whole mass and all the external forces were applied at this point parallel to their original directions.

(2) The motion of a rigid body *relative* to the centre of gravity is the same as if the centre of gravity were fixed.

These two propositions constitute the *Principle of the independence of the motions of translation and rotation.* According to this principle, it is possible to consider *separately* the motion of translation of the centroid or centre of gravity (to which the equation $F = M.a$ will apply) and the motion of rotation of the body about the centroid (to which the equation $E = Ia$ will apply).

Let us take a simple example to illustrate the practical application of this principle. In general, however, its application involves the use of the Differential and Integral Calculus.

Example.—A string is wound round the circumference of a disc, 1 foot in diameter and weighing 2 lb. One extremity of the string is attached to a fixed point, and the disc is allowed to fall. The friction between the string and the disc is such as to prevent slipping of the disc. It is required to investigate the resulting motion and to find the tension in the string.

Let AB represent the string, C the centre of gravity of the disc, and T the unknown tension in the string (Fig. 35). Since the weight acts vertically downwards, there is no force acting on the disc horizontally and the string will therefore remain vertical.

Applying the principle of the independence of the motions of translation and rotation we have:

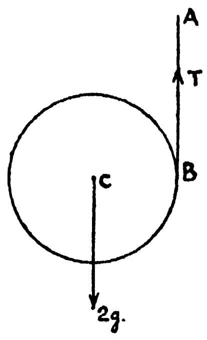


FIG. 35.

(1) As regards the motion of translation of the centre of gravity, the forces acting on the disc are its own weight $2g$ vertically downwards and T vertically upwards. These forces must be supposed to be acting at C, which point is also supposed to contain the whole mass. The resultant external force is thus $2g - T$, and therefore

$$2g - T = 2f \quad . \ . \ . \quad \text{(i)},$$

f being the linear acceleration of C.

(2) As regards the motion of rotation about C, the weight $2g$, acting at C, has no moment about C, and the moment of T about C is $T \times$ the radius of the disc $= T \times \frac{1}{2}$. This is the resultant moment of the external forces about C.

$$\text{Hence } T \times \tfrac{1}{2} = Ia \quad . \ . \ . \quad \text{(ii)},$$

a being the angular acceleration of the rotation.

Since there is no slipping between the disc and the string, a length of string equal to the circumference of the disc will be unwound in the time the disc makes one complete revolution. Hence the point C will fall a vertical distance equal to $2\pi \times$ the radius of the disc $= 2\pi \times \frac{1}{2}$, in the time the disc turns through an angle 2π. Hence the linear distance s, described by C in a very small interval of time t, is equal to the angular distance θ through which the disc rotates in time t, multiplied by the radius r of the disc,

$$i.e. \quad s = \theta \times r$$

$$\frac{s}{t} = \frac{\theta}{t} \times r.$$

But $\frac{s}{t}$ is the linear velocity v of C, and $\frac{\theta}{t}$ is the angular velocity w of the disc

$$\therefore \quad v = wr$$

$$\text{and} \quad \frac{v}{t} = \frac{w}{t} r.$$

But $\frac{v}{t}$ is the linear acceleration f, and $\frac{w}{t}$ the angular acceleration a

$$\therefore \quad f = ar \ . \ . \ . \ \text{(iii) or } a = \frac{f}{r} = \frac{f}{\frac{1}{2}} = 2f \ . \ . \ . \ \text{(iii)}$$

$$\text{Also} \quad I = MK^2 = 2K^2.$$

Substituting these values for a and I in equation (ii) we have

$$\tfrac{1}{2}T = 2K^2.2f = 4fK^2$$

$$\therefore \quad T = 8fK^2 \quad . \ . \ . \quad \text{(iv)}$$

Add (iv) and (i) then

$$2g = 2f(1+4K^2),$$

$$\therefore \quad f = \frac{g}{1+4K^2}.$$

Now K^2 for a disc rotating about an axis perpendicular to its plane is

$$\frac{r^2}{2} = \frac{1}{4} \Big/ 2$$

$$f = \frac{g}{1+\frac{1}{2}} = \frac{2}{3}g.$$

Hence the disc drops with an acceleration equal to $\frac{2}{3}$ of that of a body falling freely. Knowing the acceleration, the velocity at any moment and the distance fallen in any given time can be easily calculated.

Substituting for "f" in equation (i) we have

$$T = 2(g-f) = 2(\tfrac{1}{3}g).$$

The weight of the disc being $2g$, the tension in the string is thus seen to be equal to $\frac{1}{3}$ of the weight of the disc.

This problem has been dealt with at some length because it illustrates both an important principle and the mathematical method of applying principles to the solutions of problems. The principle is that of the independence of the motions of translation and rotation. Attention must be drawn to the method of solution. This consists essentially of two steps—first the writing down of equations which express the laws to which the motion conforms, and secondly the solution of these equations for the unknown terms contained in them. Thus, equation (i) expresses the law in accordance with which the disc falls vertically, while (ii) is obtained in conformity with the law under which the motion of rotation takes place. These two equations contain three unknown quantities, viz. T, f, and a. The second step of finding the values of three unknown quantities, T, f and a, from only two equations, cannot therefore be taken unless we know of some relationship which exists between any two of these unknowns. Hence the formation of equation (iii), viz. $f = ar$ which supplies this required relationship. The solution of the problem then becomes purely a question of Algebra.

The principle of the independence of the motions of translation and rotation leads at once to an important deduction, viz. *The total kinetic energy of a body must = kinetic energy due to its motion of translation + the kinetic energy due to its motion of rotation.* I will illustrate this by showing how the preceding problem might be solved from this point of view of kinetic energy.

Suppose the disc, starting from rest, falls a vertical distance s. Its total kinetic energy is the gain in kinetic energy owing to its falling a distance s, and this is equal to the work done by the external forces acting in the direction of its motion. The only force acting in this direction is that of gravity, which is equal to Mg., *i.e.* $2g$, the mass of the disc being 2 lbs.

Hence the total kinetic energy $= 2\ gs$.

If v is the vertical, linear velocity and w the angular velocity acquired by the disc during its fall, the kinetic energy of translation is $\frac{1}{2}Mv^2$, and that of rotation is $\frac{1}{2}MK^2w^2$.
Hence

$$2gs = \tfrac{1}{2}M(v^2+K^2w^2) = \tfrac{1}{2}\cdot 2(v^2+K^2w^2) = v^2+K^2w^2,$$

an equation which expresses the preceding law of energy.

Also $\quad v = wr$ or $w = \frac{v}{r}$ (p. 570) and $K^2 = \frac{r^2}{2}$

$$\therefore \quad 2gs = v^2 + \frac{r^2}{2}\cdot\frac{v^2}{r^2} = \frac{3}{2}v^2$$

$$\therefore \quad v^2 = 2\left(\frac{2}{3}g\right)s.$$

But a body starting from rest and moving with acceleration f will, in travelling a distance s acquire a velocity v given by $v^2 = 2fs$. Comparing this with the last equation, it follows that the vertical acceleration of the disc is $\frac{2}{3}g$, a result which agrees with the one obtained by the preceding method. The tension of the string could now be found by substituting this value of the acceleration in the equation $2g - T = 2f$.

Power.—The *rate* at which work is performed, or the quantity of work done in each second, is called the *Power* of the agent or machine which supplies the operating forces. In F.P.S. units, the unit of power is a foot-pound of work per second. A Horse Power is defined as 33,000 foot-pounds per minute or 550 foot-pounds per second. In c.g.s. units, the unit of power is the Watt, which is equal to 10^7 or 10,000,000 ergs of work per second.

If F is the force exerted in its own direction through a distance s in a time t, then the work done by that force in time t is F.s, and the work done in 1 second, *i.e.* the power $= \frac{F.s}{t}$.

If t is small, then the power necessary to perform a given work Fs is correspondingly great. Hence great power implies the ability to perform work in a short time.

As a practical example, let us find the horse-power exerted by an engine driving a ship, weighing 1000 tons, at a uniform speed of 10 miles an hour, if the resistance amounts to 25 lbs. per ton.

The force opposing the motion is $1{,}000 \times 25 = 25{,}000$ lbs., and 10 miles an hour $= \frac{44}{3}$ feet per second. Hence this force is overcome through

a distance of $\frac{44}{3}$ feet in every second, and the work done is $25000 \times \frac{44}{3}$ foot-pounds in every second, which is the power exerted by the engine. The horse-power $= \frac{25000 \times 44}{3 \times 550} = 666\frac{2}{3}$.

Again, what would be the horse-power necessary to drive the same ship at double the speed, if the resistance is known to vary as the square of the speed ?

Doubling the speed quadruples the resistance, which thus becomes 100 lbs. per ton, and the opposing force is 100,000 lbs. And since the speed is $\frac{88}{3}$ feet per second, the necessary horse-power becomes $\frac{100,000 \times 88}{3 \times 550} = 8 \times 666\frac{2}{3}$. Hence the required horse-power varies as the *cube* of the speed, which will help the reader to realise why very great increase in engine-power is required, in order to obtain an increase in speed of but a few knots per hour.

Power is frequently transmitted from a machine generating the power to another machine where the power is to be utilised, by means of a belt passing round two pulleys or wheels. In such a case there is a difference in tension between the upper and lower portions of the belt (Fig. 36). Suppose this difference in

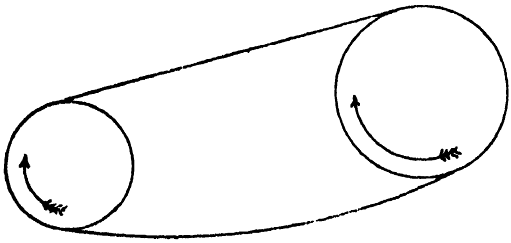


FIG. 36.

tension to be 1000 lb., then this is the value of the driving force. If, further, the belt move with a velocity of 500 feet a minute, then this force is moved through 500 feet in each minute, and the work done is $1,000 \times 500$ foot-pounds per minute. The horse-power transmitted is therefore $\frac{1,000 \times 500}{33,000} = 15 \cdot 15$.

Law 3.—" *To every action there is an equal and opposite reaction.*"

Every action between two bodies must necessarily be of the nature of a " pull " or a " push," or, as it is usually termed, a *tension* or a *pressure*. The law states that this action is mutual in character. An object resting on a table exerts a pressure downwards on the table, and the table at the same time " reacts " by exerting an exactly equal pressure upwards ; the result is consequently equilibrium. If one holds one end of a string, to the other end of which a weight is tied, the pull of the hand on the string is exactly equal and opposite to that of the string on the hand, and the pull of the weight on the string is also exactly balanced by that of the string on the weight ; the forces occur *in pairs*. If the hand be raised so as to lift the weight, then at the commencement of the motion the action on the string is greater than its reaction on the hand, and motion takes place in the direction of the greater force in accordance with the Second Law ; but when the motion has become uniform and the weight is rising with uniform velocity and no acceleration, then the mutual actions and reactions must again be exactly equal, in accordance with the First Law. In dealing with actions between two bodies, full account must be taken not only of the action of one body on the other, but also of the reaction of the second on the first.

This is illustrated in the following three examples :

Example 1.—A uniform rod AB of weight W is pivoted at P and rests on a peg at Q. What is

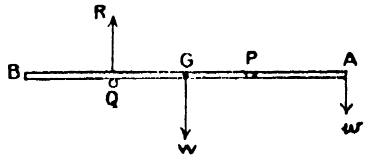


FIG. 37.

the least weight which placed at A will just lift the rod off the peg ?

Let G be the middle point. The total weight W of the rod will act through G. As long as the rod is in contact with the peg at Q, it exerts on the peg an unknown pressure downwards which we will call R. This downward pressure is already fully accounted for, as it forms part of the force W, which is the resultant of a large number of forces including the downward force at Q. We now have to take into account the reaction of the peg on the rod, and this is a force equal to R, but in an upward direction.

Let w be the weight attached at A ; its effect will be to reduce the mutual action between the rod and peg. By taking moments about P we have, when there is equilibrium :

$$w.\text{AP} + \text{R.QP} = \text{W.GP}.$$

$$\therefore \quad \text{R} = \frac{\text{W.GP} - w.\text{AP}}{\text{QP}}$$

which gives the value of the mutual action between rod and peg in terms of certain distances from the pivot, the weight of the rod and the weight attached.

In the event of w *just* lifting the rod off the peg, R becomes zero and

$$\therefore \quad W.GP - w.AP = 0$$

$$\therefore \quad w = W \cdot \frac{GP.}{AP}$$

and does not depend on the position of the peg.

Example 2.—A ladder weighing 48 lb., and whose length is 25 feet, rests with one end against a *smooth* vertical wall, the other end in contact with the ground being distant 7 feet from the wall. If it be prevented from slipping by a peg in the ground, find the reactions of the peg, the ground, and the wall.

Let PQ represent the ladder; its weight acts at the middle point G. The actions of the ladder at P and Q on the ground and wall are in the vertical and horizontal directions respectively. Both these are included in W. The reaction of the ground R_g will consequently be vertically upwards, and that of the wall R_w will be horizontal. Also the reaction of the peg R_p will be horizontal and in direction PS since it prevents the motion of P in the direction PT. The ladder is, therefore, in equilibrium under the action of the forces shown in the accompanying diagram. The conditions are (1) the resultant of all the forces must be zero, and (2) the sum of the moments of the forces about any point in their plane must be zero (see p. 562). These conditions are satisfied by the following equations:

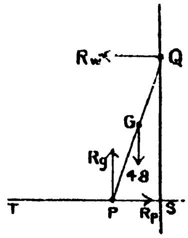


FIG. 38.

$$R_g - 48 = 0 \quad . \quad . \quad . \quad \text{(i)}$$
$$R_p - R_w = 0 \quad . \quad . \quad . \quad \text{(ii)}$$

and by taking moments about P

$$48 \times \tfrac{1}{2}PS - R_w \times QS = 0 \qquad \text{(iii)}$$

PS = 7 feet; $QS = \sqrt{25^2 - 7^2} = 24$ feet.

From (i) $R_g = 48$ lbs.

(iii) $R_w = \dfrac{48 \times \frac{1}{2}PS}{QS} = \dfrac{24 \times 7}{24} = 7$ lbs

(ii) $R_p = R_w$ and $R_p = 7$ lbs.

Example 3.—In the construction of the curved portion of a railway track the outer rail is raised above the level of the inner, so that the floor of a carriage when rounding the curve is tilted out of the horizontal. This is done to supply a force towards the centre (necessary in the case of motion in a curve), which would otherwise be obtained wholly from the action between the rails and the flanges on the wheels, with a consequent wearing away of the rails. It is required to find the height that the outer rail must be raised in order that there may be no action whatever between the rails and wheels.

Let h be the height of the outer rail B above the inner rail A; θ the angle which the line AB makes with the horizontal. Let r be the radius of the curve; s the speed of the carriage round the curve.

The acceleration of the carriage is then $\dfrac{s^2}{r}$ towards the centre (see equation 7), and if m is the mass of the carriage acting at G, the force towards the centre (in direction GC) is $m\dfrac{s^2}{r}$ poundals.

Let R_1 and R_2 be the reactions of the rails

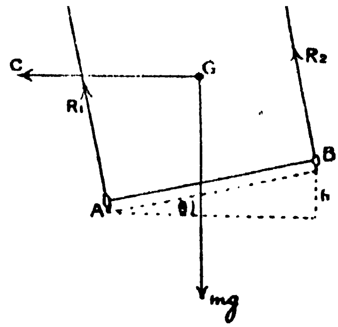


FIG. 39.

in a direction perpendicular to AB. The components of these in the vertical and horizontal directions respectively are $(R_1 + R_2)\cos\theta$ and $(R_1 + R_2)\sin\theta$. The former balances the weight of the carriage, and therefore

$$(R_1 + R_2)\cos\theta = mg.$$

The latter supplies part of the force towards the centre of the curve, and if it supplies the whole of this force, so that the action between the rails and flanges is zero, then

$$(R_1 + R_2)\sin\theta = m\frac{s^2}{r}.$$

Dividing the second of these equations by the first, we have

$$\tan\theta = \frac{s^2}{r.g.} \qquad \text{(A)}.$$

This equation gives the value of θ, and if we know the width of the track AB we can calculate h, since $h = AB \sin\theta$. Thus, for a velocity of 30 miles an hour, and a radius of curvature of 1000 feet, we should have

$$\tan\theta = \frac{44^2}{1000 \times 32} = \cdot 0605.$$

When θ is small, $\sin\theta = \tan\theta$ approximately, and $h = AB \times \cdot 0605$. If the gauge is 4′–9″, then $h = 57 \times \cdot 0605 = 3\tfrac{1}{2}$ inches approximately.

It will be noted from equation (A), that θ and consequently the height h, of the outer rail above the inner, depends both on the speed and on the sharpness of the curve, but chiefly on the speed. In practice the height h is

adjusted so that there is no pressure between the rails and flanges for trains moving with moderate velocities. In the case of trains moving at higher speeds, the pressure between the rails and flanges supplies the additional centrifugal force (*i.e.* the force towards the centre of the curve) required. In case of very sharp curves, *i.e.* r small, the driver must reduce speed when taking the curve.

D'Alembert's Principle.—In the case of the application of a force to a rigid body, not only is there action and reaction at the point of application itself, but there is action and reaction between neighbouring particles throughout the body. Consider, for example, the case of a weight supported by a string.[1] At any point such as P in the string (Fig. 40) there is a pull downward, which is balanced by a pull upward, and this is the case throughout the string and not merely at the point of suspension. But these *internal forces*, as they are called, between the particles of the rigid body, occur in pairs of equal and opposite forces, in accordance with Newton's Third Law. If we sum all those internal forces, they cancel each other and form, therefore, a system which is in equilibrium. Hence we get the principle known as the *principle of D'Alembert*, viz. "if any external forces act on a rigid body, the mutual reactions of the particles of the body may be disregarded in forming the equations of motion." This simplifies considerably the mathematics that would otherwise be required in dealing with the motion of a rigid body under the action of external forces. As a direct deduction from D'Alembert's principle we obtain by the use of a little advanced mathematics the principle of the independence of the motions of translation and rotation exemplified on p. 570.

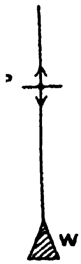


FIG. 40.

Friction is a force with which we are all familiar. No surface is *perfectly* smooth, and even the surface of a very smooth body contains small ridges and hollows. When two bodies are in contact, the ridges on one surface fit into the small depressions of the other and offer a resistance to a sliding motion of one over the other. It is this resisting force which is called the force of friction, and it always acts in a direction opposite to that in which motion takes place. Although in machines the presence of friction involves the wastage of power, yet friction is frequently of the greatest practical service. But for friction we could not grasp and hold objects; we could not walk; all the movements to which we are accustomed in our daily life would be impossible. Fast-moving vehicles are very quickly brought to a standstill by frictional forces applied by means of brakes.

If a heavy book or some other object with a flat base be attached to a string and placed on a horizontal table, and we pull gently on the string, the friction between the object and table will prevent any motion of the former. The magnitude of the resisting force must be exactly equal to the pulling force, otherwise the object would move in the direction of the greater force. If we stop pulling, friction simultaneously ceases to act, for if it did not the object would move. And if with an increase in the pulling force we still obtain no motion, it is evident that the friction called into play has also increased simultaneously with that of the force exerted. It follows, therefore, *that friction is a self-adjusting force; no more is called into play than suffices to prevent motion.* But it must be remembered that this is only true within limits; the amount of friction that is brought into play is not unlimited—a point is reached when the friction becomes a maximum, and if the force exerted on a body is greater than this, motion will ensue. This maximum value, or the magnitude of the force of friction called into play when one body is *just on the point* of sliding over another, is called *Limiting Friction.* For practical purposes, it is the value of this limiting friction that is of importance.

Naturally the limiting friction varies with different surfaces, that between smooth surfaces being less than between rough surfaces. But for any two given surfaces, the limiting friction is found by experiment to depend *only* on the pressure or normal reaction between the two bodies. The area of contact is immaterial. Hence we obtain the following:

Laws of Friction.—(1) Friction is a self-adjusting force, its direction and magnitude being such as just to prevent motion.

(2) The greatest amount of friction is brought into play when motion is about to take place; it is then called the limiting friction.

(3) Limiting friction is proportional to the pressure or normal reaction only. Hence $F = \mu R$ . . . *Equation* (16) (F representing the value of the limiting friction, and R that of the normal reaction).

μ is a constant, called the *coefficient of friction*—constant for any two given materials, but, of course, having different values for different materials. Its value can be found experimentally, and is always less than unity.

If, therefore, a body weighing 100 lbs., for example, rests on a horizontal surface, and the coefficient of friction between the two is $\frac{1}{4}$, then the maximum value of the friction is 25 lbs., the normal reaction being equal to the weight of the body. Hence such a body cannot be

[1] A taut string is equivalent to a rigid body, if there is no "give" or stretching.

made to slide unless a force slightly greater than 25 lbs. be applied in a horizontal direction. Suppose such a body resting on an inclined plane whose inclination to the horizontal is gradually increased to a value θ when the body is just on the point of sliding down; let the coefficient of friction again be $\frac{1}{4}$. In this position of limiting equilibrium the forces acting are: 100 lbs. vertically downwards, the normal reaction R

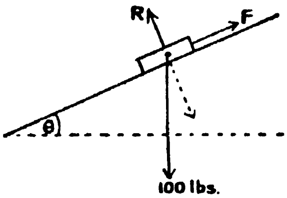


Fig. 41.

perpendicular to the plane, and the limiting friction F along the plane opposite to the direction in which motion is about to take place (Fig. 49).

Now the vertical force of 100 lbs. can be resolved into a force 100 sin θ *down* the plane, and a force 100 cos θ perpendicular to the plane (in the direction of the dotted line). Since there is equilibrium

$$100 \sin\theta = F \quad . \quad . \quad . \quad \text{(i)}$$
$$\text{and} \quad 100 \cos\theta = R \quad . \quad . \quad . \quad \text{(ii)}.$$
$$\text{But } F = \mu R = \tfrac{1}{4}R$$
$$\therefore \quad 100 \sin\theta = \tfrac{1}{4} \times 100 \cos\theta$$
$$\therefore \quad \frac{\sin\theta}{\cos\theta}, \text{ or } \tan\theta = \tfrac{1}{4}.$$

Hence the inclination of the plane to the horizontal, when motion is about to take place, is such, that the *tangent of the angle of inclination is equal to the coefficient of friction* between the two surfaces. This, therefore, provides a practical method of finding the coefficient of friction between two substances by the measurement of an angle.

(4) When motion has once taken place, the frictional resistance becomes less than the limiting friction, and is nearly independent of the velocity.

These laws relate to *sliding* friction. When a body such as a wheel rolls on the ground, *rolling* friction is brought into play, and this is very much less than the sliding friction at the axle of the wheel. Hence the value of ball bearings.

Since friction tends to prevent motion, not to originate it, it is often called a *passive* force, and when energy is spent in overcoming this force there is no equivalent amount of energy stored in the body either in the form of potential or kinetic energy. At first sight it would seem as if the energy thus expended has been destroyed contrary to the law of conservation of energy, but as a matter of fact, no such destruction of energy takes place. The energy expended in overcoming frictional forces invariably reappears in an exactly equivalent amount in the form of heat-energy. The generation of heat by friction is of too common an occurrence to require more than mere mention.

Simple Machines.—A machine is a contrivance whereby a force, termed the *power*,[1] is applied to overcome some resisting force or forces, which in the following pages will be sometimes termed the "weight." The essence of a machine is that it should either enable us to overcome a large resisting force by the application of a small power, or provide greater physical convenience for the application of the power, or do *both*. A single pulley, properly fixed, will enable us to pull *up* a weight by pulling on a rope in a *downward* direction, and since it is easier and more convenient to pull down than up, the pulley is in that sense a machine, although the actual force that has to be applied is no smaller than the weight moved.

The ratio $\dfrac{\text{resisting forces overcome}}{\text{power applied}}$ is termed the *mechanical advantage* of the machine. If the power is less than the resisting forces, this ratio is greater than unity, and it is the aim of the constructor of a machine to make the mechanical advantage as large as possible.

In all machines, part of the power is wasted in overcoming friction in the machine itself, and only a fraction of the power applied is available for the performance of the useful work for which the machine is intended. The ratio $\dfrac{\text{useful work}}{\text{whole work}}$ is termed the *efficiency* of the machine. In a perfect machine, where there is no friction at all, the efficiency is unity. This is impossible in practice, but the greater the extent to which friction is eliminated, the greater is the efficiency of the machine. In what follows, I shall assume the absence of friction.

The simpler machines are: I, The Lever; II, The Wheel and Axle; III, The Pulley; and IV, The Inclined Plane. All other machines are, in practice, combinations of these simpler ones.

I. The Lever.—This consists of a rigid bar, which may be either straight or curved, and which can turn freely about a fixed point or axis called the *fulcrum*. The power and the resisting forces to be overcome, or the "weight," are applied at certain points in the bar. The relative positions of fulcrum, power, and weight admit of three variations; hence we have three classes of levers (Fig. 42), viz. Class I, in which the fulcrum F is situated at some point between the power P and the weight W; Class II, in which the weight is situated between the power and

[1] The word power is used here in the loose, popular sense of force, and must not be confused with the meaning given to it on p. 571.

the fulcrum; and Class III, in which the power is situated between the weight and the fulcrum. The distances[1] of the power and weight from the fulcrum are called the *arms* of the lever.

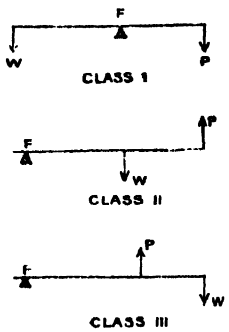


FIG. 42.

Now, in all three classes of levers let P represent the power, W the weight, p the arm of the power, and w that of the weight. In the position of equilibrium, when the power just balances the weight, the moment of the power about the fulcrum must equal the moment of the weight about the same point. Hence $P.p = W.w$, or $\frac{W}{P} = \frac{p}{w}$, which gives the mechanical advantage of the machine.

In Class I, p may be longer or shorter than w or equal to w; hence the mechanical advantage may be greater or less than unity or unity. As a rule, the power arm is greater and the mechanical advantage larger than unity. Examples of this form of lever are: a pair of scales ($p = w$); a poker when used to stir a fire, the bar of the grate forming the fulcrum; a crowbar, when used so that a point in it rests on a fixed support; a claw-hammer; the Roman and Danish steelyards, &c. A pair of scissors and a pair of pincers are examples of double levers of this class.

The steelyards, which are merely balances of a special form, require a short description. Each consists of a rigid bar, one end of which

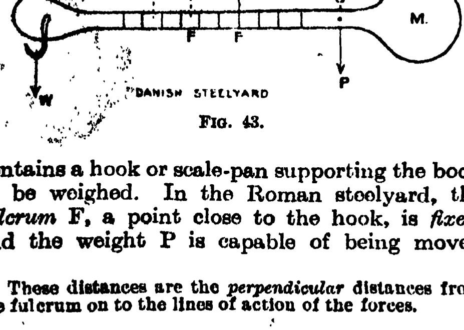


FIG. 43.

contains a hook or scale-pan supporting the body to be weighed. In the Roman steelyard, the *fulcrum* F, a point close to the hook, is *fixed*, and the weight P is capable of being moved along the length of the bar. The bar is graduated so as to read the weight supported when P is moved to any point. Thus, suppose F is 1 inch from the hook and P a weight of 10 lb. Then, when P is moved to a point 10 inches from the fulcrum, it will support a weight of 100 lbs.; hence this point would be marked 100 lbs.; similarly with the other graduations.

In the Danish steelyard the *fulcrum is movable* and P is fixed. This form of yard contains at one end a heavy lump of metal M. The centre of gravity of the bar is situated at a point G close to M. The power P, equivalent to the weight of the bar and lump of metal, thus acts at G. A weight W is suspended from the hook and the point of support or the fulcrum F is moved until the bar exactly balances. The bar is graduated in a manner similar to the Roman yard, so as to read the weight supported when the bar balances about any point in its length.

In the Second Class of levers, p is always greater than w; the mechanical advantage is thus *always* greater than unity. Examples of this form of lever are provided by: a wheelbarrow (the fulcrum is the point of contact with the ground); a crowbar when used with one end in contact with the ground; a cork squeezer; an oar—if the end in contact with the water is at rest, this end forms the fulcrum, the power being applied at the other end and the weight at the rowlock, between the two. A pair of nutcrackers is a double lever of this class.

In Class III, p is always less than w, and the mechanical advantage thus less than unity. This form of lever is used more for the convenience it affords in the application of a power than for its mechanical advantage. An example of this kind of lever is the limb of an animal. The socket is the fulcrum; the power is supplied by the action of a muscle attached to the bone near the socket, and the weight is that of the limb moved. A pair of sugar-tongs is a double lever of this kind.

Work Performed by the Power.—Although with the aid of a lever we can use a small force or power to overcome a large resistance, yet it must be noted that the work or energy expended in overcoming the resisting forces must all be supplied by the power. Hence, if a resisting force or weight of 10 lbs. be moved through a distance of 1 foot in its own direction by a power of 1 lb., then this power will have to move through a distance of 10 feet in its own direction, so that the work of 10 foot-pounds expended by the power is just equal to the work of 10 foot-pounds performed against the resisting force. Generally, if a power P move through a distance s, the weight W will be moved a distance d so that $Ps = Wd$. And if P is small compared with W, s will be proportionately large compared with d. This can be

[1] These distances are the *perpendicular* distances from the fulcrum on to the lines of action of the forces.

easily proved with the aid of the adjoining figure. We have

$$P.\,p = W.\,w \text{ or } \frac{P}{W} = \frac{w}{p}$$

Now let the force P move through a distance s, thus raising the weight W a height d, the lever AB assuming the position of the dotted line (Fig. 44). Since the two triangles FAP, FBC are

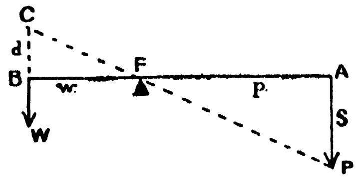


FIG. 44.

similar, $\frac{w}{p} = \frac{d}{s}$.

$$\text{Hence } \frac{P}{W} = \frac{w}{p} = \frac{d}{s} \text{ and } \therefore\ Ps = Wd.$$

A small force must, therefore, move through a great distance in order to overcome a large resistance through a short distance; in other words, the *work done by the power is exactly equal to the work done by the resisting forces*, and the lever as a machine does not help us to get a lot of work done by means of a small expenditure of work on the part of the power; in other words, it does not enable us to create energy—that is impossible. This is known as the *Principle of Work*, and is true of *all* machines. It makes it absolutely certain that never will a machine be constructed whereby energy (or work) can be created over and above that supplied by the power itself. It is left to the reader, as an instructive exercise, to prove this for himself for each of the simple machines described below.

II. **The Wheel and Axle** is but the lever over again in another form. The "wheel" has a larger radius than the axle. The weight is raised by a rope which coils round the axle, while the power is applied by a rope coiled round the "wheel" in an opposite direction. The "arms" of the power and weight are the radii of the wheel and axle respectively. If these are r_w and r_a respectively, then

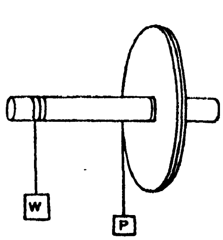


FIG. 45.

$$P.r_w = W.\,r_a.$$

The mechanical advantage is therefore $\frac{W}{P} = \frac{r_w}{r_a}$.

Theoretically, by making the radius of the wheel very large and that of the axle very small, an enormous mechanical advantage might be obtained. But this is not practicable; if r_w is very large, the machine becomes unwieldy, while if r_a is very small, the axle will be too weak and liable to break. The difficulty is, however, overcome by an ingenious modification called the Differential Wheel and Axle, which gives a large mechanical advantage without any of the disadvantages just mentioned.

The Differential Wheel and Axle contains a *double* axle, one larger than the other. The rope round the wheel and the smaller axle are coiled in the *same* direction, while the rope

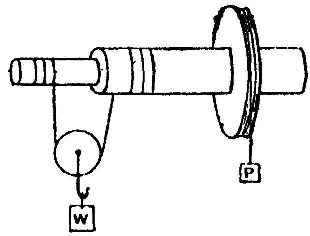


FIG. 46.

round the larger axle is coiled in an opposite direction. The action of the smaller axle is, therefore, such as to reinforce that of the wheel. If r, r_1, and r_2 are the radii of wheel, larger and smaller axle respectively, then for equilibrium we have

$$Pr + \frac{W}{2}r_2 = \frac{W}{2}r_1$$

(since half the weight is supported by each axle)

$$\therefore\ W(r_1 - r_2) = 2Pr$$

or

$$\frac{W}{P} = \frac{2r}{r_1 - r_2}$$

Hence by making r_2 very nearly equal to r_1 the quantity $(r_1 - r_2)$ becomes very small, and we obtain a large mechanical advantage.

III. **The Pulley** is a wheel grooved along its circumference to hold a rope or chain. The wheel can turn freely about an axle which is supported in a framework called the "block." If the block is attached to a fixed beam so that the pulley can only revolve on its axle, then the pulley is said to be a *fixed* one; but if the pulley, besides revolving on its axle, is also capable of moving up and down, then it is called a *movable* pulley. Fig. 47 illustrates this, A being a fixed pulley, and B a movable one. The mechanical advantage of a fixed pulley is unity; it has, however, the advantage of altering the

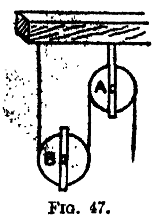


FIG. 47.

direction in which the power would otherwise have to be applied.

Pulleys arranged in a combination form a system, and there are three possible methods of arrangement.

Method I, or the First System, is illustrated in Fig. 48. The distinctive feature of this system is a separate rope round each pulley, one end of the rope being attached to the beam and the other end to the pulley immediately above. The illustration shows three movable pulleys—the fixed pulley merely changes the direction of pull without having any effect on the mechanical advantage of the system. The weight W is supported by the rope round pulley C, so that the tension T_C in the rope on each side of the pulley is $\frac{1}{2}$W. The beam thus supports $\frac{1}{2}$W and pulley B also $\frac{1}{2}$W. Half of this is in turn supported by the beam, and the remaining half by pulley A, so that $T_B = \frac{1}{2}$ of $\frac{1}{2}W = \frac{W}{2^2}$. Half of this is again supported by the beam, and the remaining half by the power P, so that

$$P = \tfrac{1}{2} \text{ of } \frac{W}{2^2} = \frac{W}{2^3}.$$

If there were n movable pulleys then $P = \frac{W}{2^n}$.

This is on the assumption that the ropes and pulleys are of negligible weight, but these weights can be easily taken into account if required. The mechanical advantage of this system is, therefore, 2^n where n is the number of movable pulleys. A small increase in the number of pulleys gives a great increase in mechanical advantage. For example, an increase from three pulleys to four increases the mechanical advantage from 8 to 16.

Method II, or the Second System of Pulleys, consists of two blocks, each block containing a number of pulleys (Fig. 49). The upper block is fixed to the beam and the lower is movable. *One* rope passes round all the pulleys, and since the tension in the one rope must be uniform, the tension in each portion of rope must be P. In the figure, the weight is shown to be supported by four portions of rope. Hence W = 4P, and if there were n portions *of rope at the lower block*, then W = nP, and the mechanical advantage is n. The weight of the rope and pulleys has again been neglected. In practice the pulleys in *each* block are arranged parallel to each other so as to turn on the same axis (Fig. 50).

Method III, or the Third System of Pulleys, is illustrated in Fig. 51. The arrangement is somewhat similar to that of the First System, with this difference—that one end of each rope is attached to the weight instead of the beam. The figure shows four pulleys, one of which is fixed. The weight W is supported by the tensions in the four ropes attached to it. The tension T_A in the rope round pulley A is equal to P. The rope round pulley B, attached to A, supports a force equal to $P + T_A = 2P$. Hence the tension $T_B = 2P$. Similarly $T_C = 2 \times 2P = 2^2P$ and $T_D = 2 \times 2^2P = 2^3P$. Hence

$$W = T_A + T_B + T_C + T_D = P + 2P + 2^2P + 2^3P = P(1 + 2 + 2^2 + 2^3)$$

$$\therefore W = P\frac{2^4 - 1}{2 - 1} \text{ by summing the progression}$$

$(1 + 2 + 2^2 + 2^3)$.

Similarly, if there were n pulleys, one of which is fixed, then

$$W = P\frac{2^n - 1}{2 - 1} = P(2^n - 1)$$

and the mechanical advantage would be $2^n - 1$.

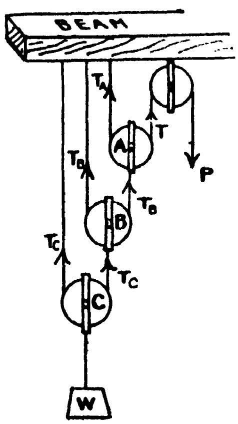


FIG. 48.

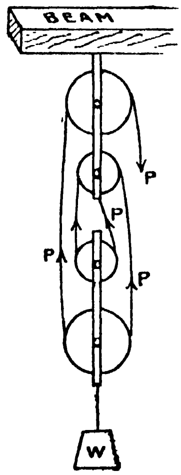


FIG. 49.

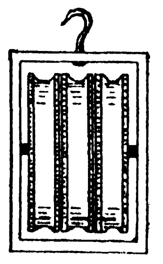


FIG. 50.

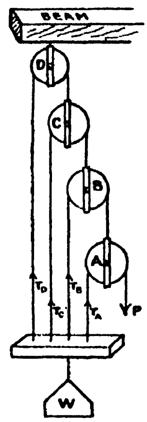


FIG. 51.

The weight of the rope and pulleys has been neglected in the calculation, but it is to be noted that the weight of the pulleys acts in the same direction as the power, and hence adds to the mechanical advantage. With this arrangement it is therefore an advantage to use heavy pulleys.

The Differential Pulley is shown in section in the adjoining figure, and is used in conjunction with a single movable pulley. It consists of two concentric wheels, of which one has a smaller radius than the other. An endless rope passes round the pulleys. The principle is exactly similar to that of the differential wheel and axle. We have $W=2T$ and if r_1 and r_2 are the radii of the larger and smaller wheels, then by taking moments about the centre we have

$$Pr_1+Tr_2=Tr_1$$

$$\therefore \quad P=T\frac{r_1-r_2}{r_1}=\tfrac{1}{2}W\frac{r_1-r_2}{r_1}.$$

By arranging to have the difference in radii very small, the factor (r_1-r_2) becomes very small and P proportionately so, and thus the mechanical advantage becomes proportionately great.

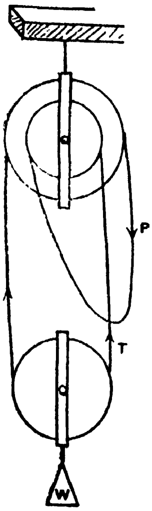


FIG. 52.

IV. The Inclined Plane is used to facilitate the raising of heavy bodies through a small height. In the case where the weight is pushed up the plane by a power P parallel to the plane (Fig. 53) we have, in the equilibrium position, $P=W \sin \alpha$

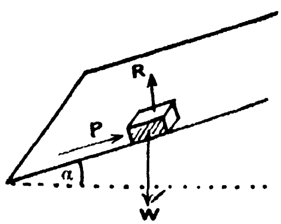


FIG. 53.

(by resolving the forces along and perpendicular to the plane; α is the angle the plane makes with the horizontal).

In the case where P is horizontal (Fig. 54), we have $P \cos \alpha = W \sin \alpha$ (by resolving forces along and perpendicular to the plane); hence $P=W \tan \alpha$.

In both cases, if α is small P becomes proportionately small. When α is very small, $\sin \alpha = \tan \alpha$ approximately, and it is immaterial whether P is applied parallel to the plane or

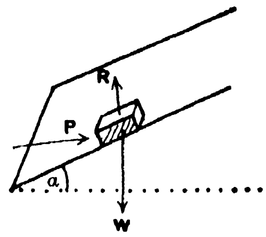


FIG. 54.

to the ground. For large angles $\sin \alpha$ is smaller than $\tan \alpha$.

The Wedge and the *Screw* are modifications of the inclined plane. The Wedge is a double inclined plane, the two planes meeting in a sharp edge. It is made of metal and is used to split substances, the edge being forced in by repeated blows of a hammer. Assume that the power P is applied at the middle point of the base AC and perpendicular to it (Fig. 55). The

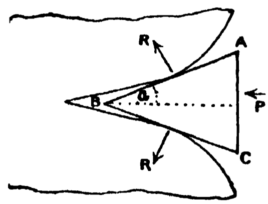


FIG. 55.

weight is the resistance 2R offered by the substance and composed of a resistance R on each plane, acting in a direction perpendicular to the plane. If α is the angle ABP of either plane, the angle between the power P and the resistance R is $(90°-\alpha)$, and the case is exactly similar to that illustrated in Fig. 53 above; hence in the equilibrium position, $P=2R \sin \alpha$.[1]

The mechanical advantage is $\frac{2R}{P}$, which equals $\frac{1}{\sin \alpha}$ and is therefore greatest when α is least. In practice, the wedge is constructed with as small an angle ABC as is consistent with its strength.

The Screw consists of a raised ridge, called the *thread*, wrapped round a cylinder in a continu-

[1] This result is obtained on the assumption that there is no friction. If, however, μ is the co-efficient of friction between the wedge and the substance, then

$$P=2R\ (\sin \alpha + \mu \cos \alpha).$$

ous spiral (Fig. 56). The thread is thus in reality an inclined plane running round the cylinder, and its inclination to the horizontal is termed *the angle of the screw.* The vertical distance A to B or B to C, &c. between any two consecutive threads is termed the *pitch* of the screw. The screw works in a nut, grooved so as to fit the thread, and as the screw turns it moves forward in a direction opposed to that of the resistance it is intended to overcome. In conformity with the principle of the inclined plane,

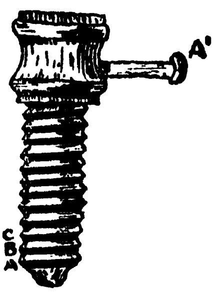


FIG. 56.

the mechanical advantage is increased in proportion as the angle of the screw is decreased. But a small angle of the screw necessarily entails having a small pitch; hence the smaller the pitch the greater the mechanical advantage of the screw, and this can be still further increased by applying the power at the end of an arm A′, instead of at the circumference of the cylinder. Where very great mechanical advantage is required, the practical problem of obtaining a strong screw with a sufficiently small pitch [1] is solved by the use of a differential screw, based on the same principles as those of the differential machines already described. The differential screw consists of a solid screw CD working inside a hollow screw AB (Fig. 57). The solid screw

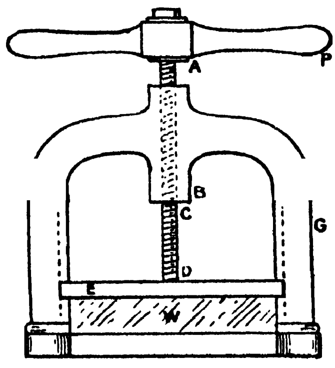


FIG. 57.

is attached to a board E which can move up and down between grooves cut in a framework FG; thus the lower screw can move up or down but cannot rotate. The power is applied at the end of the arm AP, and the substance W, to which pressure is to be applied, is placed beneath the board. If l is the length of the power arm measured from the axis of the screw, and p and p' the respective pitches of the two screws, then the mechanical advantage is $\frac{l}{p-p'}$. Thus the pitches p and p' can be made as large as we please, and yet a very great mechanical advantage obtained by making the *difference* $(p-p')$ very small.

[1] The "problem" is one of strength. A very small pitch necessitates a *thin* thread, which is liable to break.

HYDROMECHANICS

In this section the behaviour of fluids under the action of forces will be considered. The term "fluids" embraces both liquids and gases. Newton's laws naturally apply to fluids as well as solids, but there is an important difference in the properties of these two states of matter, a difference which alters and limits the conditions under which the forces act.

Distinction between Solids and Fluids.—Let ABC represent any substance, and let DE be

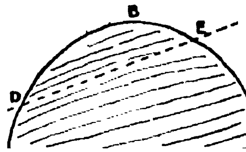


FIG. 58.

any plane, inclined to the horizontal, dividing the substance into two portions. The weight of the upper portion naturally tends to cause it to slide down the plane DE. In the case of a solid such motion does not take place; evidently forces are brought into play to prevent it. This mutual action and reaction between the two portions of the substance lying immediately above and below the plane DE is called a *stress*, and consists of internal forces which, in the case of rigid bodies, D'Alembert's principle allows us to neglect when considering the behaviour of such a body under the action of external forces. Now, this stress can be resolved into two stresses at right angles to each other—one perpendicular to the plane DE, called the *normal stress*, and the other along the plane DE called the *tangential* or *shearing stress*. A normal stress is usually accompanied by a compression or an extension according as it consists of a thrust or a pull, whereas a shearing stress is accompanied either by the substance on one side of the plane sliding over the other, or by a tendency to do so. Rigid bodies can sustain large normal and shearing stresses—the definition of a perfectly rigid body being "a body in which the relative distances and positions of its particles do not alter under the action of external forces, however great." Of course perfectly rigid bodies do not exist in practice. *All* solid bodies can, however, sustain *continued*

shearing stresses if these are sufficiently small. *No fluid, on the other hand, can sustain a continued shearing stress, however small.* This statement forms a comprehensive definition of a fluid, and also expresses the essential difference between solids and fluids. If the substance ABC of the last figure consists of a fluid, the portion above the plane DE will not remain in equilibrium; it will slide down, and it may do so either quickly, as would be the case with water, or slowly, as would be the case with pitch. The important point is that the fluid will yield *in time* to the *smallest* shearing stress, although it may resist a considerable shearing stress if applied for a short time only. Thus a sudden blow may produce no perceptible impression on a lump of pitch, whereas a similar blow will make a dent in a lump of putty. The putty will, however, resist a small shearing stress for an indefinite time, whereas the pitch will not. The putty is a *soft solid,* whereas the pitch is a *hard liquid.*

We therefore arrive at the following important proposition, viz. *when a fluid is at rest the stress across any plane in it is entirely normal to that plane.* It follows, therefore, that the exposed surface of any fluid at rest must be horizontal.

It does not follow that this is also true for fluids in motion. Place equal quantities of water and treacle in separate tumblers, and set them rotating by means of a spoon. If there were no shearing stress to prevent the sliding of one portion of the liquid over the other, they would continue rotating indefinitely, but as a matter of fact the motion ceases in a short while, the treacle coming to rest much sooner than the water. We infer, therefore, that in the case of fluids in motion the stresses are not entirely normal and a shearing stress *does* exist; hence the surface of a liquid in motion need not necessarily be horizontal. Further, the tangential resistance to the sliding of one portion of the liquid over the other is evidently greater in the case of the treacle than in the case of the water. This is expressed by the statement that the treacle is more *viscous* than the water. In any consideration of the motion of a liquid, the *viscosity* of the liquid, a value which varies from one liquid to another, must therefore be taken into account.

Viscosity is thus similar to the phenomenon of friction, with the action of which we are so well acquainted in connection with solids. When a fluid is at rest, the question of viscosity naturally disappears, just as the question of friction does in the case of a book resting on a horizontal surface under its own weight, when there are no forces at work tending to slide the book along that surface.

There are, however, certain important differences between friction and viscosity which must be noted. (*a*) Friction is the force resisting motion between two surfaces of two bodies; viscosity is the force-resisting motion between two surfaces of the same liquid. (*b*) Friction is a variable force, but with a maximum limiting value, depending on the two surfaces and the normal reactions between them but independent of the velocity; viscous resistance is also a variable force depending on the nature of the liquid but with no limiting value—its value varies directly with the velocity of relative motion between one part of the liquid and another.

Pressure Exerted by a Fluid.—It has been found that at sea-level the atmosphere exerts a pressure of nearly $15\frac{1}{2}$ lbs. on every square inch. On rising to heights above sea-level, this pressure diminishes, and at very great heights it becomes small, but wherever there is air, there it is found to exert a pressure on objects immersed therein. Similarly, every gas and liquid is found to exert a pressure, *i.e.* a force, on the walls of the vessel in which it is contained, or on any surface to which it has access. If a hole be made in the side of the vessel, the fluid will, owing to this pressure, be pushed out. Now suppose we have a vessel, area of cross section 2 square feet and filled to a height of 6 inches with a liquid. What is the pressure on the floor of the vessel, the floor being horizontal? Omitting atmospheric pressure, the only force acting on the floor of the vessel is the weight of the liquid resting upon it, *i.e.* the weight of 1 cubic foot of the liquid. This is the *total* downward thrust and not the pressure. The word "pressure" means the thrust on *unit area,* and in this case the pressure on the floor of the vessel is equal to the weight of $\frac{1}{2}$ cubic foot of the liquid. Reasoning in the same way in general terms, if h be the height of the liquid in the vessel, the volume of liquid resting on unit area of the floor of the vessel, is h cubic feet or cubic centimetres, according as the English or French system of units is being used. If ρ is the mass of unit volume of the liquid,[1] its weight will be ρh, and the pressure will be a *weight* of ρh lbs. (or ρh grammes) or a *force* of $g\rho h$ poundals (or $g\rho h$ dynes).

If we consider any one point on the floor of the vessel, the pressure on that point is indeterminate since a point has no dimensions. *Pressure at a point* is, therefore, defined as the pressure on unit area surrounding that point on the assumption that throughout this area the pressure is constant. Hence the pressure at a point in a fluid, h units vertically below the surface, is $g\rho h$. It follows that the pressure must be the same at all points in a horizontal plane since all such points are equidistant from the surface.

Now it can be proved both theoretically and experimentally that the pressure at a point in

[1] The mass of unit volume of a substance is called its *density.*

a fluid is the same in *all directions.* At a point A in the wall of a vessel (see Fig. 59) distant h from the surface, the pressure is not only $g\rho h$ vertically downwards (tangential to the wall) but also $g\rho h$ in a direction perpendicular to the wall. This is the force with which the fluid would be forced out were there a hole at that point in the side of the vessel, and it is the force which that point of the vessel must withstand. The total thrust on the side of the vessel can therefore be calculated. In the case of a curved side, the calculation is rather difficult, but in the case of a plane side (or plane area) it is simple. For if A is the area immersed and H the depth of the water, the pressure at any point being $g\rho h$, the pressure varies evenly from zero at the surface where $h=0$ to $g\rho$H at the bottom where $h=$H. We can therefore take an average, viz. $g\rho\frac{H}{2}$ for the pressure at every point, and the total thrust on the area immersed will be $Ag\rho\frac{H}{2}$. Since this only depends on the area of the surface immersed and the depth of the water, it is easy to understand how the gate of a lock can keep out the waters of the ocean, provided the depth is not too great.

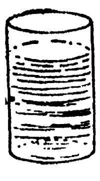


FIG. 59.

Applications.—Consider the position of rest which a liquid in two vessels A and B joined by a connecting pipe, PQ, must necessarily assume (Fig. 60). In PQ, draw any cross section

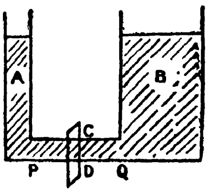


FIG. 60.

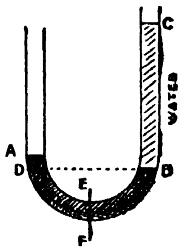


FIG. 61.

CD. This area is in equilibrium under two pressures—one due to the liquid in A and one to the liquid in B. These are equal to $g\rho h$ and $g\rho h'$ respectively, if h and h' are the heights of the liquid in A and B respectively. Hence, as there is no motion of the liquid, $g\rho h = g\rho h'$, or h must equal h'. If not, there will be a flow of liquid from one vessel to the other until h does equal h'. It is to be noted that the total volume of liquid in each vessel does not affect the question at all; it is entirely a question of depth. Hence the phrase " water finds its own level "; as a matter of fact, any liquid finds " its own level."

If in a vessel similar to the above we have two liquids of different densities, and such that they do not mix, the height of the liquid in each limb, when the equilibrium position has been reached, can again be found in a manner similar to the above. Let the two liquids be mercury and water, for example, AB representing the mercury and BC the water (Fig. 61). Draw BD horizontal, and let AD $=h$ and BC $=h'$.

In the position of equilibrium the pressures on each side of a cross section such as EF must be equal. The pressures due to heights FD and FB of mercury are equal; hence the pressure due to height DA of mercury must be equal to that due to height BC of water, or $g\rho h = g\rho' h'$, where ρ and ρ' are the densities of mercury and water[1] respectively.

$$\therefore \quad \frac{h}{h'} = \frac{\rho'}{\rho}$$

The heights of the liquids (above the common level provided by one of them) are therefore inversely proportional to their densities. In the case under consideration, that of mercury and water, the density of mercury is 13·5 times that of water. The height of the water above B will therefore be 13·5 times as great as the height of the mercury above B or D. A column of mercury 1 cm. in height will support a column of 13·5 cms. of water; 2 cms. of mercury will support 27 cms. of water, &c. Again, it is to be noted that the width of the limbs of the vessel illustrated in Fig. 61 (a vessel called a U tube) is of no consequence.

Such an arrangement as the one just described, can be employed to measure pressures of gases. All we have to do is to balance a column of gas against a column of liquid. This is done in

The Barometer.—A long glass tube, closed at one end, is filled with mercury. The open end is then closed with the finger and the tube inverted over a dish containing mercury; the finger is removed when the open end is below the surface of the mercury in the dish. If the tube is of sufficient length, the mercury in it will fall to some point such as B (Fig. 62), which, however, will be about 29 inches above the surface A of the mercury in the dish. The space CB is a vacuum, and there is no pressure at the surface B. If we imagine the tube bent and continued as indicated by the dotted line, right to the limits of the atmosphere, we then have a case precisely similar to that illustrated in Fig. 61. The pressure exerted by the atmosphere which fills the imaginary tube is balanced by the pressure exerted by the column of mercury AB, which is equal to $g\rho h$, ρ being the density of mercury and h its height. Atmospheric pressure is usually expressed in terms of

[1] 1 c.c. of water weighs 1 gramme, while 1 c. ft. of water weighs 1000 ozs. or 62½ lbs. Hence the density of water is unity, if C.G.S. units are used, and 62½ if F.P.S. units are employed. Similarly, the density of mercury or any other fluid depends on the system of units adopted. This is important when making calculations.

h, either as equal to so many inches or so many millimetres of mercury. The pressure of the atmosphere does not remain constant; it varies with the temperature of the air, the quantity of moisture present, and with the motion of large masses of air. "Normal" atmospheric pressure is taken as 760 mms. of mercury.

A tube filled with mercury, inverted and clamped over a mercury trough (Fig. 62) is called a *barometer*. The tube is graduated, so that the height of the mercury in it above the surface of the trough can be easily read. The function of the barometer is simply to register atmospheric pressure, which is known to have a direct influence on the weather about to be experienced. There are many varieties of barometers, but all depend on the same principle.

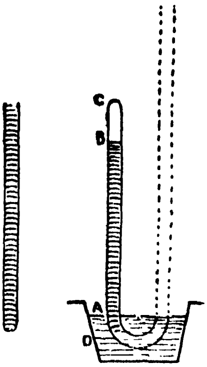


Fig. 62.

Of course any other liquid, such as water, might be used. But the density of mercury being 13½ times that of water, the height of the water barometer would be 13½ times that of the mercury one, viz. about 32 feet 6 inches—rather an inconvenient height. Hence the universal use of mercury.

Pressure Gauges are an application of the same principle. To measure pressures nearly atmospheric, a tube containing mercury such as shown in Fig. 63 is sufficient. The pressure of the

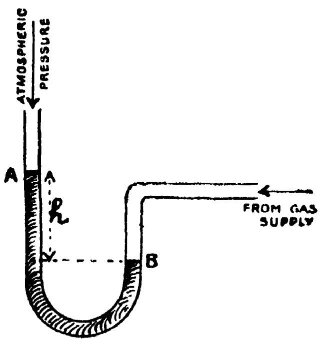


Fig. 63.

supply is then equal to atmospheric pressure $+ h$. Thus if A is 10 cm. above B and the barometer stands at 760, then the pressure is $760 + 100 = 860$ mms. of mercury. If the pressure from the supply is less than atmospheric pressure the level of B will rise and that of A drop to some distance "*h*" below B. The pressure is then equal to $760 - h$.

For high pressures an air manometer is used. This will be described later.

Hydrostatic Machines.—All these work on the principle that difference of pressure causes a flow of fluid from a point at high pressure to one at a lower pressure.

The Syringe is too common an instrument to require detailed description. When the piston has been pushed down to its lowest position, the nozzle is inserted into the liquid. The piston is then drawn back (to position P say) and as it fits the sides fairly closely, a partial vacuum is formed in the space S (Fig. 64). The pressure in S is now less than atmospheric; the pressure at N is slightly greater than atmospheric; as a result, the liquid is forced through the nozzle and fills the syringe as the piston is drawn back. The action is sometimes described as one of *suction;* a similar instance is the case of a liquid being sucked into the mouth through a straw. The same principle applies to gases as well as liquids; we draw air into the lungs by enlarging the walls of the chest and increasing the space into which the lungs can expand; the internal pressure then becomes less than atmospheric and air enters to equalise the pressures.

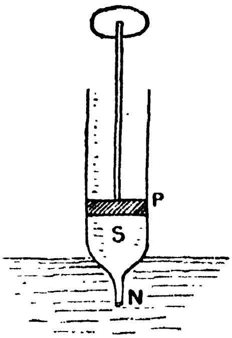


Fig. 64.

The Siphon is a bent tube ABC, open at both ends, by means of which a vessel can be emptied of liquid without moving the vessel itself (Fig. 65). One end A must be inserted into the

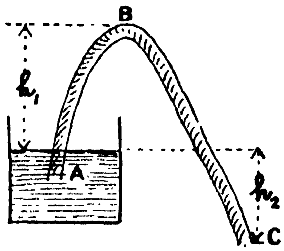


Fig. 65.

liquid, and the other end C must be well below the level of the liquid in the vessel. The siphon must be *started*, as the liquid will not, of its own accord, rise to B. To do this, the mouth is applied to C and the tube filled by suction, or the tube is first filled with liquid, the ends are sealed, one end is inserted in the liquid in the manner illustrated and the ends are then opened. Once the tube has thus been filled a difference of pressure exists between the ends

A and C which will produce a continuous flow from A to C.

If P is the atmospheric pressure, h_1 the vertical height of B above the surface of the liquid, h_2 that of C below the surface, and ρ the density of the liquid, then

The pressure at the surface is P.

The pressure within the tube at $B = P - g\rho h_1$ (since h_1 is negative, being above instead of below the surface).

The pressure within the tube at $C = P + g\rho h_2$.

The pressure without the tube at $C = P$.

Hence there will be a flow of liquid from A to B, at C there will be a flow outwards which will leave a partial vacuum and cause a flow from B to C. Thus we get a continuous flow round the siphon—from A to B, from B to C, and from C outwards.

Further, the pressure at B will be zero when $P = g\rho h_1$ and cannot be less than zero. This will be the case when h_1 is the height of a barometer filled with the same liquid as the one under investigation, and h_1 cannot have a value greater than that. The greatest possible height of a siphon is therefore that of a barometer filled with the same fluid. Thus, if the water-barometer stands at a height of 32 feet, water cannot possibly reach a height of more than 32 feet.

The Common Pump is shown in section. It consists of a cylinder AB which communicates, by means of a narrower cylinder BC, with a reservoir R from which the water is to be raised. Within the larger cylinder, a piston PP works between B and DE, where the spout is situated. This piston contains a valve V_2 which opens upwards; a similar valve V_1 is also placed at B, the junction of the two cylinders.[1] The action of the pump is as follows: Suppose the piston initially at B and both barrels filled with air. As the piston is raised, a partial vacuum is produced in BP; the atmospheric pressure closes the valve V_2 and opens V_1. Air then enters from CB into the upper cylinder; the pressure in CB is thus reduced, and water rises in it from the reservoir. When the piston is forced down, the air in PB is compressed; this closes the valve V_1 and opens V_2, allowing the air to escape. The upward stroke of the piston is then repeated, and the water rises higher in CB. After a few strokes, the water enters the cylinder BA. On the next downward stroke it is forced through the valve V_2 and lifted out through the spout when the piston rises again. The one essential condition for the working of the pump is that the height CB must be less than the height of the water barometer,[1] otherwise the water will not enter the upper cylinder. In practice, owing to the imperfection of valves, it is found that the maximum height must be several feet below that of the water-barometer.

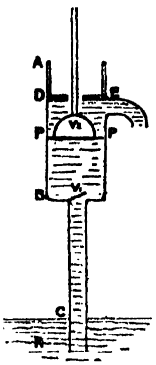


FIG. 66.

[1] A *valve* is a contrivance which allows a fluid to pass in one direction but not in the other. A simple form of valve consists of a leather disc closing an opening and hinged so as to open in a particular direction. Thus the valve V_1 in the figure will open upwards under pressure from below and allow liquid to pass from the smaller to the larger cylinder, but will close down under pressure from above and prevent liquid from passing in the reverse direction.

The Lift Pump (Fig. 67) is a modification of the preceding, the vertical pipe RQ, provided with a valve V_3, taking the place of the spout. By its means, water can be lifted to a great height provided the pump is sufficiently strong. This form of pump is in use at central water-supply stations, the water being first raised from the reservoir to a great height before entering the system of pipes which supplies the district. Unless this were done first, the water in any building would not rise to any floor which is above the level of the reservoir.

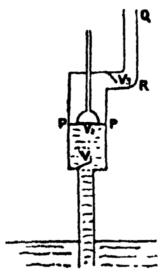


FIG. 67.

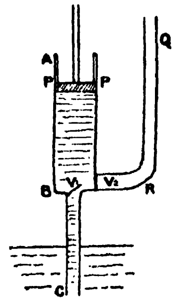


FIG. 68.

The Force Pump.—In this form of pump the piston is solid and has no valve (Fig. 68). The vertical pipe is placed at the bottom of the upper barrel instead of at the top as in the lift pump. The water rises in CB, and through the valve V_1 fills the upper barrel in the same manner as in the common pump. In the next descending stroke of the piston, the valve V_1 closes, V_2 is forced open, and the water in the upper barrel driven into and up the tube RQ. The flow through the tube is thus intermittent, only taking place on every downward stroke of the piston. To obviate this and obtain a continuous flow, the tube RQ is led out of the lower part of a chamber K which is partially filled with air (Fig. 69). On the downward stroke of the piston the water is forced into the chamber K and up the tube. The air in the chamber is thus compressed. On the next upward stroke of the piston the valve V_2 closes, and the compressed

[1] The height of the water barometer is usually about 33 feet.

air in the chamber, in attempting to regain its original volume, keeps up a continuous pressure on the water in K and thus continues the flow through the tube.

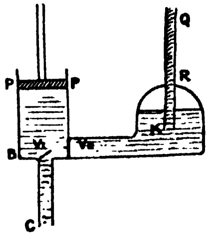


Fig. 69.

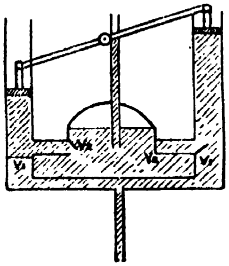


Fig. 70.

The Fire Engine (Fig. 70) consists of a double force pump, provided with an air chamber. The two pistons are attached to the opposite ends of a lever, so that one descends while the other ascends.

Transmissibility of Fluid Pressure.—"If any pressure be applied to the surface of a fluid, it is transmitted equally to every point of the fluid." This proposition can be proved experimentally.

Bramah's or the *Hydrostatic Press* is an application of this principle, to which it also provides an experimental proof. The press (Fig. 71) consists of a force-pump, the piston P of which is of very small section. The pipe from it leads into a large, strong cylinder A of much larger section, containing a watertight cylinder P′. On pressing down the piston P this pressure is transmitted to *every point* of the liquid in A, so that

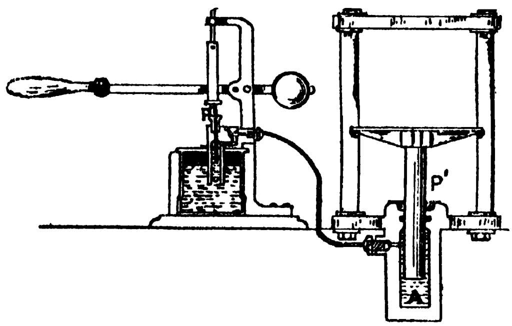


Fig. 71.

if the section of P′ is 100 times that of P the upward force on the former will be 100 times as great as the downward force on the latter. Theoretically we could, by making P small enough and P′ large enough, multiply the force applied to any extent, but this possibility is limited in practice by the strength of the sides of the vessel which would have to support the pressures put upon them.

Brahma's Press affords a good example of the Principle of Work described on p. 577. If the cross section of P′ is 100 times that of P, the latter would have to be pushed down a distance of 100 inches to raise P′ a distance of 1 inch. Thus the work done on P would be exactly equal to that performed by P′.

Distinction between a Liquid and a Gas.—A liquid is *practically* incompressible. For example, it would require a pressure of over 3000 lbs. to the square inch to reduce a given volume of water by one-hundredth part. The compressibility of a liquid is therefore negligible, and, for moderate depths, the density of a liquid remains constant throughout. Not so, however, with gases. They yield readily to pressure and expand readily on a reduction of pressure, so that a gas may be described as "a fluid, a given portion of which can be made to expand indefinitely so as to fill any space, however great, by sufficiently diminishing the pressure." Since the volume of a given mass of gas varies, it follows that its mass per unit volume or its density is, unlike that of a liquid, a variable quantity. Thus, if we have a given mass of gas in a closed vessel, and an additional quantity is crowded into the same space, the density of the gas will become greater. The pressure at any point in the air near sea-level is equal to the weight of a column of air extending to the limit of the atmosphere, and which rests on a unit horizontal area surrounding that point. The air at sea-level is consequently more compressed than at higher levels—in other words, the density of the air gradually diminishes as we rise to heights above sea-level.

Since a gas will expand so as to fill all the space to which it has access, the pressure of a gas enclosed in a vessel is practically the same at all points in the vessel. The pressure at the bottom of the vessel will be greater than that at the top by $g\rho h$ (h being the height of the vessel), but as ρ, the density, is a very small quantity in the case of gases, this is negligible. The pressure exerted by a gas enclosed in a vessel obeys a very simple law: "The pressure of a gas varies inversely as the volume, if the temperature remains constant." This is known as Boyle's Law, so named after an Englishman who first investigated the question experimentally in 1661. (See p. 629.)

Until comparatively recent times it was thought that Boyle's Law was perfectly accurate, but more careful experiments have proved that it is not so. It is, however, extremely near the truth for gases which are difficult to liquefy, such as air, oxygen, hydrogen, and nitrogen.[1]

Applications of Boyle's Law.—The Diving Bell

[1] For a discussion as to the reasons for this, see article on Physics, p. 629.

consists of a large, heavy, hollow, bell-shaped vessel, made of metal and capable of holding several persons. It is closed at the top and open at its lower end. It is lowered into the water by means of a chain, and carries with it

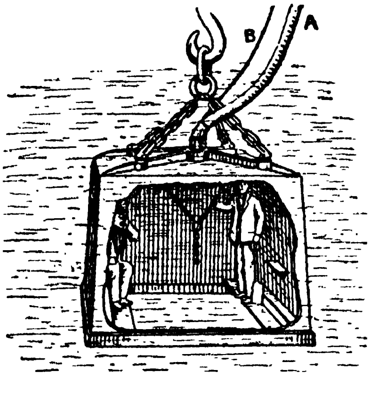


FIG. 72.
A, Air Tube; B, Telephone.

the air it contains. As it sinks into the water the pressure of the contained air, being always equal to that of the water with which it is in contact, increases. The volume of the air will consequently diminish according to Boyle's Law, and the water will rise within the bell. To prevent this, air is forced down into the bell through a tube. The surface of the water inside the bell can thus be kept at any desired level. The chief object of the apparatus is to enable men to go to the bottom of deep water and there perform work, such as the laying of the foundations of piers, &c.

The Air Manometer is an instrument for measuring high pressures such as those found in the boilers of steam engines, or the receiver of a condenser, &c. A simple form is a U tube containing mercury. One limb A is closed and contains some dry air, while the other limb B is open and communicates with the chamber in which the pressure is to be measured. When the pressure in the chamber is equal to that of the atmosphere, the mercury surfaces in the two limbs will be on a level. When the pressure in the chamber is greater than that of the atmosphere, the mercury in the left-hand limb will rise to some point such as P, and that in the right-hand limb will be depressed by an equal amount to Q. The pressure in the chamber then equals (pressure in AP + pressure of column of mercury PQ′). The pressure in AP can be calculated by means of Boyle's Law, and thus the pressure in the chamber found. In practice a scale is attached to the left-hand limb, and from it the pressure corresponding to any level P of the mercury can be directly read.

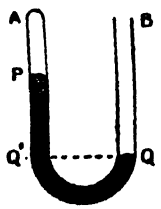


FIG. 73.

The *Condenser Gauge* is a simpler form of manometer. It consists of a long glass tube

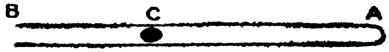


FIG. 74.

AB, closed at A and open at B so as to communicate with the vessel in which the pressure is to be measured. At the end A is some dry air separated from B by a drop of mercury C, which also acts as a pointer. The pressure must be the same on each side of the drop. As the pressure in the vessel increases, the drop is forced towards A, the air in A is compressed, and the pressure in AC increases according to Boyle's Law. Thus the tube can be graduated so as to read the pressure corresponding to any position of the drop of mercury.

Charles' Law.—The relation between pressure and volume of a gas, as expressed by Boyle's Law, depends on the temperature remaining unaltered during the change in volume. If now the pressure is kept unchanged, the volume will change with temperature in such a manner, that it will increase by $\frac{1}{273}$ of the volume occupied at 0° C. for every degree Centigrade rise in temperature. This is known as Charles' Law; it is also frequently called Guy Lussac's Law. From this law we can, by an application of Boyle's Law, deduce the change in pressure of a gas with change in temperature, when the *volume remains constant*. (See p. 630.)

Solids Immersed in a Liquid—Archimedes' Principle.—Suppose a solid immersed in a liquid. What are the conditions which will decide whether the solid will sink or float? The forces acting on the solid are (1) its own weight vertically downward, and (2) the resultant thrust [1] of the liquid on the solid.

To find the value of the resultant thrust, suppose the solid removed and the gap filled up with the liquid. This substituted liquid would be in equilibrium under two forces: (1) its own weight acting vertically downwards through its centre of gravity, and

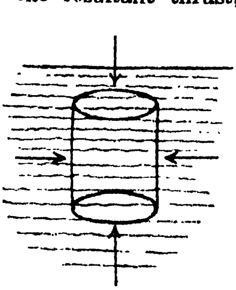


FIG. 75.

1 By "resultant thrust" is meant the resultant of a number of thrusts, viz. of the total thrust vertically upwards on the bottom surface, of the total thrust vertically downwards on the top surface, and of the total thrust on the sides (Fig. 75).

(2) the resultant thrust of the surrounding liquid on it. The latter must, therefore, be equal to the former and act vertically upwards through the centre of gravity of the former.

Hence *the resultant thrust of a liquid on a solid, wholly or partially immersed therein, is equal to the weight of the liquid displaced by the solid, and acts vertically upwards through the centre of gravity of this displaced liquid.* This is Archimedes' principle or theorem—probably the most important principle in Hydrostatics. The centre of gravity of the displaced liquid is called the *centre of buoyancy.*

The problem as to whether a solid will sink or float in a liquid is now solved. If the solid is heavier than the liquid it displaces, it will sink; if lighter, it will float; if of exactly the same weight, it will just float when totally immersed. Consider this with respect to the most common liquid of all—water. The condition that a solid may float in water depends on the ratio

$$\frac{\text{weight of the body}}{\text{weight of an equal volume of water}}$$

If this ratio is greater than unity, the solid is heavier than the water it displaces and will sink; if the ratio is less than unity, it will float; and if equal to unity, it will just remain totally immersed. If this ratio is $\frac{1}{2}$, the solid will float with half its volume immersed; if $\frac{5}{8}$, then $\frac{5}{8}$ of its volume will be immersed, &c. This ratio for any substance (always considered with reference to water) is called the *specific gravity* of the substance.[1] The specific gravities of substances such as wood, cork, &c., are less than unity, while those of iron, copper, &c., are greater than unity.

Specific gravity must not be confused with density. The value obtained for the density of a substance depends on the units of measurement adopted. Specific gravity, being a ratio, is independent of the units adopted. If, however, the French system of units is used, the specific gravity of a substance will in all cases be found to be exactly equal to its density. This is frequently the cause of confusion between the two.

What is true of a solid immersed in a liquid is equally true of a liquid immersed in another liquid. Hence we require to know the specific gravities of liquids. The specific gravity of mercury being about 13·5, mercury will sink in water, but oil will float, its specific gravity being less than unity.

Knowing the specific gravity of a solid and that of a liquid, we can at once state whether the given solid will float in the given liquid or not. For example, will iron float on mercury? This is determined by the ratio

$$\frac{\text{weight of iron}}{\text{weight of an equal volume of mercury}}$$

the iron will float or sink according as this ratio is less or greater than unity. Now

$$\frac{\text{weight of iron}}{\text{weight of an equal volume of mercury}}$$
$$=\frac{\text{weight of iron}}{\text{wt. of equal vol. of water}}\div\frac{\text{wt. of equal vol. of mercury}}{\text{wt. of equal vol of water}}$$
$$\frac{\text{specific gravity of iron}}{\text{specific gravity of mercury}}$$

Hence if the specific gravity of the given solid is less than that of the given liquid it will float, and if greater it will sink in the liquid. The specific gravity of iron is about 7·7, while that of mercury is 13·5—iron, therefore, floats on mercury as easily as a cork does on water.

A solid piece of iron will sink in water, but if it be beaten out so as to form a hollow vessel it will float. The reason is simple. The volume of water the iron displaces is now far greater than the actual volume of the iron itself. The iron vessel will sink into the water to such a depth that the volume of water displaced is equal to 7·7 times the volume, not of the vessel, but of the iron contained in the vessel. If we place weights in the vessel, it will sink lower still, until the weight of water displaced is equal to the total weight of the vessel plus the weights contained therein. Hence the possibility of an iron ship.

Archimedes' principle is as true for a solid immersed in a gas as it is for one immersed in a liquid, viz. the resultant thrust of a gas, on a solid immersed therein, is equal to the weight of the gas displaced by the solid and acts vertically upwards through the centre of gravity of the displaced gas. And just as we can make a piece of iron which is heavier than water float on water, so we can make a solid which is heavier than air rise from the ground and remain suspended in the air. We have only to apply the same principle and devise a means of making the solid displace a far larger volume of air than its own volume. This is done in

The Balloon, which consists of a very large, light, and nearly spherical silken envelope. This is filled with a gas such as hydrogen or coal gas, which is very many times lighter than air. To the envelope is attached a light car capable of holding one or more persons. Provided the gas bag is sufficiently large, we have all the conditions necessary to cause the entire arrangement to rise from the ground to a height which will be considered presently. For example, suppose the gas bag to be a sphere of 7 metre radius. Its volume, when fully inflated, will be $\frac{4}{3}\pi r^3$, *i.e.* $\frac{4}{3}\times\frac{22}{7}\times\frac{(700)^3}{1}$ c.c.

[1] Lack of space does not admit of a description of the experimental methods whereby the specific gravity of a substance is found. This is, however, to be found in any elementary text-book on Hydrostatics.

Now 1 c.c. of air weighs ·0013 gramme. The weight of air displaced will therefore be

$$\frac{88}{21} \times \frac{100 \times 700 \times 700 \times 13}{10{,}000 \times 1{,}000} = 186 \cdot 85 \text{ kilogrammes.}$$

If the gas bag is filled with hydrogen, since 1 c.c. of hydrogen weighs ·00009 gramme, the weight of the hydrogen will be

$$\frac{88}{21} \times \frac{100 \times 700 \times 700 \times 9}{100{,}000 \times 1{,}000} \text{ kilos.} = 12 \cdot 94 \text{ kilos.}$$

Supposing the car and its contents to weigh 140 kilogrammes, the total weight of the balloon will be 152·94 kilos, and the resultant upward thrust one of $(186 \cdot 85 - 152 \cdot 94) = 33 \cdot 91$ kilogrammes in weight. The balloon will, therefore, leave the ground with an upward acceleration f, given by

$$33 \cdot 91 g = 152 \cdot 94 f, \text{ or } f = \cdot 22 g.$$

As the balloon rises, the density of the air, and consequently the weight of the air displaced, diminishes. The upward thrust, therefore, gradually decreases and the upward motion of the balloon will cease when it has reached such an altitude that the weight of air displaced is exactly equal to that of the car plus the contents of the gas bag. The investigation at this point becomes rather complicated owing to the fact that at the new altitude the atmospheric pressure is less than it was at the commencement of the ascent. The hydrogen will, therefore, expand and the envelope will displace a larger volume of air than it did at first. Temperature effects in accordance with Charles' Law still further complicate the problem, and if the altitude is great the diminution in the value of g must also be taken into account.

Stability of Floating Bodies.—In the preceding remarks, only the conditions necessary to cause a body to float in a liquid have been considered. For practical purposes such as shipbuilding, more than this is required, viz. *stable* equilibrium, so that if the boat is slightly displaced from its position of equilibrium, forces should come into play which will turn the boat back into its original position. Unless this is achieved, the boat would very soon "turn turtle."

When a body floating in a liquid is in a position of equilibrium, the necessary conditions are that the resultant force and resultant couple must be zero (see p. 562). It follows, therefore, that in the equilibrium position the centre of buoyancy and the centre of gravity of the body are *in the same vertical straight line.* If the body be pushed, vertically, further down into the liquid the resultant upward thrust, or the force of buoyancy, will be increased, and will therefore tend to raise the body back again to its original position; if the body be vertically raised from the liquid, the force of buoyancy will be diminished and the weight of the body will tend to sink it back again to its original position. For *vertical displacements, therefore, the equilibrium of a floating body is stable.*

Let us next consider a displacement produced by a very small rotation about a horizontal axis —in other words, a displacement produced by a "pitching" motion either sideways or up and down. Illustration (*a*) (Fig. 76) represents in section the equilibrium position, the centre of gravity G of the body and the centre of buoyancy H, being in the same vertical straight line. Illustration (*b*) represents the position produced by a small rotation about the horizontal axis AX.[1] In this position, the position of G has remained unchanged with reference to the body itself, but that of H has moved to H′. If a vertical line H′M be drawn to intersect the line HG (the line joining the original centre of buoyancy with the centre of gravity) in M, so that M is above G, then the forces acting are: (1) a force through G equal to the weight of the body acting vertically downwards, and (2) an equal force through H′ acting vertically upwards. These constitute a couple tending to turn the body *back again to its original position* of equilibrium. If, however, G is situated high up and H low down, so that H′M intersects the line HG in a point M situated below G, as illustrated in (*c*), then the resulting couple will have the effect of tending to turn the body *still further*

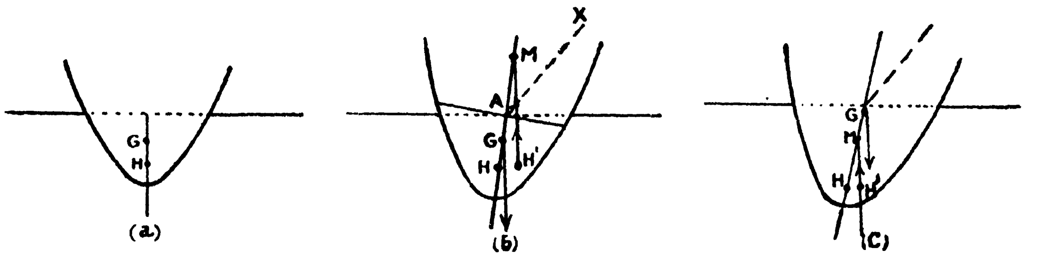


FIG. 76.

[1] The rotation must be a small one, because we are going to assume that the volume of liquid displaced remains the same.

away from its original position of equilibrium. M is called the *metacentre,* and the condition for stable equilibrium is that *the metacentre must be situated above the centre of gravity of the body.* If M coincides with G, the equilibrium is neutral.

The problem, therefore, resolves itself into one of determining the position of the metacentre, a matter of some difficulty, its position depending chiefly on the shape of the body. We see at once, however, that to ensure the stability of a floating body, its centre of gravity must be kept as low as possible. To do this, a ship always carries ballast when short of cargo.

Aviation.—The problems connected with flight are numerous and still in the experimental stage. The science of aerodynamics is as yet imperfect, and the greater part of all true experimental work still has to be carried out by the pilot whose laboratory is the air itself, wherein he puts theories to the crucial test of practice.

Restricting ourselves to fundamentals, the problem of aviation is of a twofold nature: (1) the problem of supporting the machine in the air, and (2) the problem of driving it in any desired direction and at any desired altitude. The attempt to solve the first problem has resulted in two types of machine: (*a*) the lighter-than-air machine, and (*b*) the heavier-than-air machine.

The balloon is an example of type (*a*). The large envelope when inflated with a light gas such as coal-gas makes the whole combination lighter than the air it displaces, and "up" it goes. But the pilot has no control over it; it is at the mercy of the winds. All he can do is to rise higher by throwing out ballast, or sink lower by pulling a valve which allows some of the gas to escape. In this way he seeks an altitude where the air currents should happen to be favourable. For purposes of aviation the balloon is therefore a very crude arrangement.

The airship, or the dirigible, is another example of type (*a*). In this machine the double problem is solved by two distinct means, viz. a gas bag to provide the necessary "lift," and a propeller worked by an engine to drive the machine forward. The gas bag is cigar-shaped instead of circular, as in the balloon, so as to reduce head resistance. A car running lengthwise is suspended from the envelope, and carries the passengers and necessary engines. The action of the propeller is such as to throw the air astern, and the reaction (Law 3) drives the airship forward. Rudders are also provided which act in the same manner as in a boat—the rudder offers a large surface to the fluid so as to resist the motion in the original direction, and the reaction slowly turns the head of the boat in the desired direction. Height control is in large measure attained by the provision of fins or rudder-like balancing surfaces. The airship thus gives the pilot good control; it is also safe as long as the gas bag is sound. But these advantages are more than counterbalanced by many obvious disadvantages. It is bulky and flimsy—at high velocities the gas envelope and structure generally, cannot sustain the necessary stresses; it opposes a great resistance to rapid motion; it takes time to inflate; it is very expensive, a single inflation of a Zeppelin with gas costing between £200 and £300, and the envelope only retains the gas for a limited period, besides many other disadvantages.

The *aeroplane* is a heavier-than-air machine —that is, its weight is greater than that of the air it displaces. In structure it closely resembles that of a bird—a long body with a long "wing" or plane placed symmetrically on each side of the body. This machine solves problems (1) and (2) simultaneously, and depends on the principle that action and reaction are equal and opposite. In the case of a bird, the flapping wings drive the air downwards with great force and the reaction floats the bird in the air. Some of the air is also driven astern and the reaction drives the bird ahead. So with the aeroplane.

An aeroplane is supplied with a propeller made to turn very rapidly by an engine; the reaction of the air on the propeller drives the aeroplane forward. The large planes or wings, tilted at an angle to the direction of flight, meet with a resistance to this forward motion. This resistance resolves into two forces (Fig. 77),

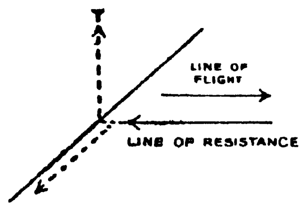


FIG. 77.

one tangential to the plane which has practically no effect, and one vertically upwards, called the upward thrust, and denoted in the figure by T. It is this upward thrust which, if sufficiently great, supports the machine in the air.

Owing to the resistance of the air, a stream of air will be pushed downward by the plane as the latter drives forward. If a is the angle

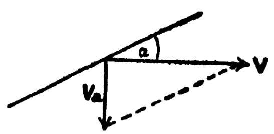


FIG. 78.

of the plane, *i.e.* the angle which the plane makes with its line of flight, and v the forward

velocity of the plane, then v_a, the velocity with which the air is forced down, is given by $\frac{v_a}{v}$ = tan a, or

$$v_a = v \tan a \quad . \; . \; . \; (i). \qquad \text{(see Fig. 78)}$$

If m is the mass of air (in lbs.) driven downwards *in a second*, then, since the force varies as the momentum generated in unit time (Newton's Second Law),

$$T \text{ (in poundals)} = m \times v_a$$

$$\text{or } T \text{ (in lbs.)} = -$$

and this must be equal to the weight w (in lbs.) of the machine together with its contents.

$$\therefore \quad m \times v_a = w.g. \quad . \; . \; . \; . \quad (ii).$$

Each plane is built in the form of a rectangle of length l and breadth b (Fig. 79). If A is the area swept out by the plane in a second, then

$$A = v.l \quad . \; . \; . \quad (iii).$$

If ϱ is the density of the air and p the height of

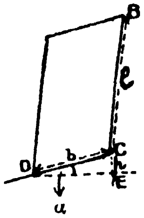


FIG. 79.

C above D, measured perpendicular to the line of flight (Fig. 79), then

$$p = b \sin a$$

and $$m = v_a \times A \times p \times \varrho \quad . \; . \; . \quad (iv).$$

Substituting from (iii) and (iv) in (ii), we have

$$v_a^2 \times v.l \times p \times \varrho = w.g,$$

and substituting from (1) we have

$$v^3 \tan^2 a \times l \times p \times \varrho = w.g.$$

and since for horizontal flight $p = b \sin a$.

$$\therefore \quad v^3 \tan^2 a \times l \times b \sin a \times \varrho = w.g. \quad . \; . \; . \; . \quad (v).$$

In constructing an aeroplane, we must know its total weight (with passengers, engine, &c.) and the velocity to be attained. Equation (v) will then help us to find "l," the span of wing required. In actual practice the breadth "b" is usually 6 feet, and a varies from 1° to about 14°. ϱ is about ·08, *i.e.* 1 cubic foot of air weighs ·08 lb. To take a concrete example: Required an aeroplane to weigh (with contents) 500 lbs. and to travel at 50 feet a second (34·1 miles an hour approx.). Suppose a to be 10°. Then

$$\sin a = \cdot 174 \text{ and } \tan a = \cdot 176.$$

$$\therefore l = \frac{w.g}{v^3 \tan^2 a \times 6 \sin a \times \cdot 08.} \quad \text{(from equation v)}$$

$$= \frac{500 \times 32}{(50)^3 \times (\cdot 176)^2 \times 6 \times \cdot 174 \times \cdot 08} = 49\cdot 5 \text{ ft. nearly.}$$

Hence such a machine would require two planes (one each side of the body) each of about 25-ft. span, or four planes each of about 12½-ft. span.

This is on the assumption that the air is still. Allowance can, however, be made for the power of the wind. Thus for the purpose of calculating the lift or upward thrust, in the case of a machine travelling with a velocity of 50 feet a second against a wind of 30 feet a second, v must be taken as 80 feet a second. The pilot makes allowance for the wind by altering the tilt of his machine and thus increasing or decreasing the factor p.

In practice the planes of the aeroplane are curved, thus imitating the wings of a bird, as shown in section in Fig. 80; it has been found

FIG. 80.

to give greater lifting effect and less "back pull." The machine is also provided with rudders which work in two planes—in the horizontal and vertical planes. The former turns the machine to the right or left, while the latter will tilt it so as to increase or decrease the angle a which the plane makes with its line of flight. Since the upward thrust $= \frac{mv \tan a}{g}$ an increase in a gives a greater upward "lift" and the machine accordingly rises to a higher altitude, while a decrease in a results in a decrease of lift and the machine drops to a lower altitude.

From the preceding theory it is also evident that the machine will not leave the ground until a certain minimum velocity has been first attained. An aeroplane is consequently provided with three wheels; when the propeller is started the machine is first driven along the ground, and when the required minimum velocity has been attained the aeroplane will rise slightly; the pilot then makes use of his vertical rudder to tilt his machine up a little and so further increase the upward thrust on his planes and thus soar into the air.

It is impossible in a short article such as this to deal with any of the numerous problems that present themselves in connection with the aeroplane, such as air "pockets," form and size of engine, form of propeller, head resistance, &c. The reader interested in the subject will find a list of books in the Reading Course to which he can refer.

In conclusion, I may add that there is little hope that flying machines will ever be small in size. Air being about $\frac{1}{800}$th part of the weight of water, both the propeller and planes must be large so as to act on an enormous volume of air in order to put any appreciable weight of it in motion. Nature herself is limited by this fact, for the largest birds known weigh only about 30 lbs. and have an enormous span of wing surface—10 to 12 square feet in area.

COURSE OF READING

There are two sides to the study of this subject, the theoretical and the practical side. A complete study would embrace both, starting with theory and applying the theory to practice.

The principles of Mechanics are few in number and simple and easy to grasp. The reader who is content with a broad outline of those principles and their application should read:

Experimental Mechanics, by R. S. Ball (Macmillan & Co.). This consists of a course of lectures which are descriptive and illustrated by numerous experiments.

Power, by Charles E. Lucke (Columbia University Press). The bulk of the subject-matter is concerned with apparatus and machinery for converting natural energy in any of its available forms into useful work, together with explanations of the physical processes for the execution of which each apparatus was devised.

The Romance of Modern Mechanism, by Archibald Williams (Seeley & Co.), gives the reader interesting descriptions in non-technical language of machinery, mechanical devices, and delicate scientific instruments.

The theoretical study of the subject is more difficult. The interpretation of the mechanical principles, simple in themselves, into mathematical language and the consequent manipulation of mathematical terms and quantities can only be achieved after long study and much practice. The subject being Applied Mathematics, it is essential first to obtain a certain minimum knowledge of mathematics to apply, just as a workman must first purchase his tools to apply them to his purpose. The reader who is content with an elementary theoretical knowledge should first master some Elementary Algebra, Geometry, and a little Trigonometry (see p. 545).

Armed with the knowledge thus obtained, the student can proceed to read Elementary Mechanics itself from any of the following:

Mechanics and Hydrostatics for Beginners, by Loney. Greater detail will be found in a slightly more advanced form in two volumes by the same author, viz. *Elements of Statics* and *Elements of Dynamics*, both published by the Cambridge University Press; or *Elementary Mechanics*, by Jessop and Havelock (G. Bell & Sons); or *Elementary Mechanics*, by Goodwill (Clarendon Press). *The ABC of Hydrodynamics*, by Lieut.-Col. R. de Villamil (E. F. N. Spon & Co.).

These books do not deal with Aviation or Aerodynamics. For this, read *Principles of Aeroplane Construction*, by R. Kennedy (J. & A. Churchill), which gives a simple exposition of the principles involved, together with numerous diagrams illustrating the text; it also contains practical examples illustrating the formulæ to be applied and the calculations to be made. *The Art of Aviation*, by R. W. A. Brewer (Crosby, Lockwood & Sons), is of a more practical nature.

For a more popular account, read *Aerial Navigation of To-day*, by Charles C. Turner (Seeley & Co.), or *The New Art of Flying*, by W. Kaempffert (Dodd, Mead & Co., New York).

I have deliberately refrained from giving a long list of books. It is not advisable for a student to attempt to read many text-books on the subject—they are all so much alike. But having chosen one's text-book, it should be read very carefully, and above all numerous examples should be worked. It is a mistake not to do so, as examples help not only to fix and retain the section read, but also aid the student to realise points which had not been properly grasped. The common experience is to leave a lecture or a book with the impression that the subject-matter has been thoroughly understood, but when an attempt is made at an example, it is found that some important step in the reasoning has either been forgotten or but imperfectly appreciated.

For a more advanced course in Mechanics the student must first embark on a hard course of reading in Advanced Mathematics. This should include Advanced Algebra, Trigonometry, Solid Geometry, Analytical Geometry, Differential and Integral Calculus, and Differential Equations. Numerous text-books are to be found on all these. To mention but a few:

Algebra, a Treatise by C. Smith; or *Advanced Algebra*, by Hall and Knight.

Trigonometry, Parts I. and II., by Loney.

Solid Geometry, by C. Smith.

Analytical Geometry, "Conic Sections," by

C. Smith or by Todhunter; or *Co-ordinate Geometry*, by Loney.

Differential and Integral Calculus, by Edwards. This also contains a few chapters on Differential Equations. A large and very advanced volume on Differential Equations has been written by Forsyth.

The student would, after such a course, be in a position to read advanced books on Mechanics such as the following:

Statics, by Loney (Cambridge University Press); or *Statics*, by Lamb (Cambridge University Press), which also includes Hydrostatics.

Dynamics of a Particle, by Tait and Steele (Macmillan & Co.); or *Dynamics of a Particle and of Rigid Bodies*, by Loney (Cambridge University Press).

Treatise on Hydromechanics, by Besant and Ramsey (G. Bell & Sons).

M. ZAKTRAGER, B.Sc. (Lond.).

ASTRONOMY

Introduction.—Recently a young man whose eyesight was bad at last provided himself with suitable glasses. It was in winter, and that very night the heavens, as they so often are, were " thick inlaid with patines of bright gold." For the first time in his life he really saw the stars, and so impressed was he with their beauty and wonder that he spent most of the night out-of-doors in sheer rapture at the sight. When he began to inquire at his friends, to whom such starlit nights were familiar, as to some of the more conspicuous of the celestial objects, he was surprised to find that they very soon came to the limit of their knowledge.

Such cases are doubtless not uncommon, and it is one of the objects of this article to remove that reproach of ignorance from the mind of the intelligent observer. Man has not been content to admire the beauty of the midnight sky; its mystery has been a challenge to him in all ages. Though much is yet unexplained, many riddles have been solved—with no lessening of the sense of wonder—and in the discovery of those solutions the mind of man has become greater, and, as a sort of by-product, contributions have been made to the store of knowledge that are proving of inestimable value to the race. In the case of astronomy wisdom has been justified of her children even from a material point of view.

The Constellations.—Probably the first thing one wishes—and it is essential for our study—is to be able to identify the chief constellations and stars. This can only be done fully by using a star atlas, but in order to make this article as self-contained as possible the irreducible minimum is given here.

It is very likely that on a brilliant starry night the sky will show such a blaze of stars that the beginner will have some trouble in identifying the chief constellations. It is therefore advisable when possible to begin the study on a night when there is a certain amount of moonlight. This will obscure the lesser lights and allow the more conspicuous ones to be more readily picked out (Fig. 1).

One can hardly be wrong in assuming that everybody knows the Plough (1), which is part of the constellation Ursa Major, or the Great Bear. It may not be seen in the position shown in the diagram, it may appear to the left or right, it may be standing on its head, but on any clear night it is always visible somewhere. The two end stars are called the Pointers, because they point almost exactly to Polaris, or the Pole Star (2) which is the end star of the Little Bear's tail. At whatever time of the night or of the year this star is observed it is always in the same position, and any one facing it is looking due north. It is not directly overhead, though in the centre of the diagram. By measuring the height of the Pole Star above the horizon the latitude of the observer can be

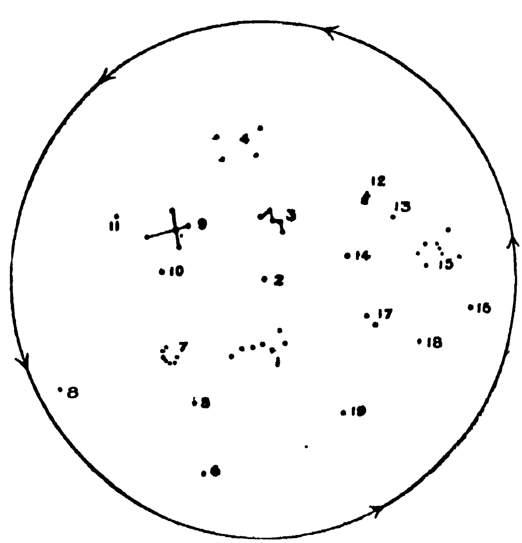


FIG. 1.

found, as is shown in the Geography article. To an observer at the North Pole the star is directly overhead. As a matter of actual fact, the real pole of the heavens does not exactly coincide with the Pole Star, but for a beginner the difference is negligible.

On the other side of the Pole Star from the Plough, and about the same distance away is the constellation Cassiopeia (3), shaped like the capital letter W, and therefore easily recognisable. A large number of the constellations take their names as this one does from Greek mythology.

Continuing beyond Cassiopeia to a distance about as great again from Polaris, you come to the great Square of Pegasus (4). In reality it is a trapezium, and one of the four stars does not belong to the constellation Pegasus at

all, but to the neighbouring constellation of Andromeda.

Returning now to the Plough, a line continuing the plough handle backwards will pass through Arcturus (5), one of the brightest stars in the heavens, and of an orange colour. It is the brightest star in the constellation Bootes. Continuing the same curve still farther you come to Spica (6), in Virgo. Arcturus is prominent in Spring and Summer; Spica is one of the stars of Spring.

When Arcturus has been identified a beautiful semi-circular constellation of six stars can be seen to the left. This is Corona Borealis (7), and lower down in the sky is a constellation which never rises high above the horizon. This is Scorpio, and in it is a fiery-red star called Antares (8), so called as rivalling Ares or Mars. It can only be seen in the summer months.

The Milky Way.—In the Milky Way, which needs no description, one of the most brilliant constellations is Cygnus (9), shaped roughly like a cross. One of the faint stars in Cygnus is our nearest stellar neighbour in this hemisphere. Between Corona Borealis and Cygnus is Lyra, the brightest star of which is called Vega (10). Nearer the horizon than Cygnus is Aquila, containing Altair (11), a first magnitude star.

Another very conspicuous object in the sky is the Pleiades, or Seven Sisters (12). This is part of a larger constellation called Taurus, whose brightest star is Aldebaran (13). It is a red star. The yellowish star nearer to Polaris is Capella (14), which competes with Arcturus and Vega for the distinction of coming second in order of brightness among the stars. It is in Auriga.

The most brilliant constellation of all is Orion (15); it contains two stars of the first magnitude and five of the second. Note that the term magnitude applies only to brightness, and has no reference to size. The three, slanting downwards in the middle, representing the belt of Orion, point to Sirius (16), much the brightest star in the heavens. Orion and Sirius contribute greatly to the glory of the winter sky. Higher in the sky than Sirius are Castor and Pollux (17), lower than these is Procyon (18), and Regulus (19), a first magnitude star in Leo, is to the left.

Any one who has made himself familiar with these will find no difficulty in completing for himself the topography of the heavens. But there is no good whatever in merely reading the pages of a text-book or of this article; advantage must be taken of every starry night to study the constellations till they are fixed in the mind. A few further remarks may be given as a help in attaining this object.

If you can find a friend with whom to work you will both lighten the labour, such as it is, and at the same time greatly increase the interest. Note that though all the stars shown in the diagram are visible at some time or other in Britain, they are not all visible on any one night. Some stars are circumpolar, including the Plough, Cassiopeia, Capella, and Vega, and these are always visible, but the two last may lie so near the horizon as to be practically invisible, especially in the south of England. The stars which are not circumpolar are below the horizon during some part of the day or night. If you watch the sky for an hour or two at night you will find that the stars on the eastern horizon are rising higher in the sky, while those on the western horizon are sinking lower and eventually setting. The circumpolar stars, on the other hand, wheel majestically round the pole star, but never set. Thus when Milton's Il Penseroso outwatches the Bear he spends the whole night in meditation.

Camera Records.—Any one with a camera may make a most interesting record of the nightly movement of the heavens. If the camera is pointed to the Pole Star and the film exposed for a few hours each star will trace out on the film a part of a circle depending in length on the time of exposure.

The whole diagram, then, rotates in the direction shown by the arrows, and the rotation is completed once in a sidereal day. The difference in time between a sidereal and a solar day is easily found. If from any definite point of observation a star is seen, in a particular place that can be noted with some accuracy, exactly above a church spire, say, and the time at which it is in that position noted for several successive nights, then the time between two successive similar positions of the star is a sidereal day, and by comparing it with the time recorded by your watch you can find the difference between a sidereal and a solar day. In observatories, clocks keeping sidereal time are used.

One very definite direction as to using the diagram may be allowed. Stand so as to face south. Lie on your back and hold the diagram over your head. Turn it round until the Plough is in its proper relative position. Then the other stars are also in their proper position. The exercise of a little imagination will save the trouble of adopting any inconvenient posture. It is important to notice that the right-hand side of the diagram represents the western horizon and not the eastern.

Mention may be made of a very ingenious and inexpensive chart—Philips' Planisphere—which shows the principal stars visible for every hour of the year.

The beginner may, indeed generally will, see one or more bright objects not mentioned in the above account, brighter than most of the stars. These are planets. If there is any uncertainty as to whether it is a planet that is observed a few days will settle the matter, for the planets do not keep the same relative

distance from the stars, and this shifting of position is decisive.

Features of the Constellations.—When once the constellations have been identified an opera- or field-glass or a small telescope will reveal much of great interest. The Pleiades, for instance, are remarkably beautiful seen in that way. In Orion is to be seen the finest nebula in the heavens. Below the belt of Orion are to be seen three stars stretching downwards—the sword of Orion. Even with the naked eye on a clear night a certain indistinctness may be seen around the middle star of the sword, and with an opera-glass this is seen to be a cloudy light. As a photographic object this is one of the most wonderful that the heavens can show. In Andromeda is another nebula that is visible to the unaided eye, and is seen well with a binocular. Then there are many star clusters that well reward the observer for his pains in seeking them. One of these is in Perseus, to the left of Cassiopeia. If the first limb of the W of the latter constellation is bisected at right angles the bisector will lead you to the cluster, which is a double one, visible to the naked eye, and a wonderful sight even with a field-glass. Another interesting occupation is the search for double stars. There is an enormous number of these, and some are visible with very low magnification, one or two with the naked eye. A number of the stars in the constellation Lyra are double, one of the most interesting of them is Epsilon Lyræ, which is close to the top left-hand corner of Vega. Each component of the double is really itself double, as seen under high magnification. The second star to the left of Vega also is a double, visible to the naked eye.

The beginner must be warned that it is not a very easy matter to find a nebula or cluster or double with a binocular or small telescope. Its position may look simple enough on a chart, but when it comes to directing the glass to the heavens all sorts of irritating difficulties may arise. These can be overcome with patience and perseverance. Do not let uncertainty about the constellations be one of these difficulties. If you're not sure which is Vega, you are likely to be only half-hearted in your search for Epsilon Lyræ. If you have a small telescope by all means get a stand for it if you can; the swaying and shaking of the instrument when held in the hand adds enormously to the trouble, and causes unnecessary exasperation. But steady persistence will eventually have its reward.

Once you have done this work, which ought to give you many an evening's pleasure, you will find yourself asking all sorts of questions. What is a nebula? Are the double stars really double or are they simply stars which happen to be near each other in the line of vision? What is the explanation of the colours of the stars? Are their distances known, and if so, how? What is the Milky Way? Do the stars move at all? Why do the planets appear to change their position? What do we know of the moon, of the sun? These and hosts of other questions will rise in the mind, and when that is so you are ready for a more systematic study of Astronomy.

THE SOLAR SYSTEM

Mention has already been made of the planets, and as these form part of the Solar System, and as our own earth is one of them, it is with this system that we shall begin.

Certain facts must be stated, and wherever figures are stated the idea is not so much to give exact numbers as to enable the student to form as accurate a mental picture as possible of the system in its entirety.

The Planets.—The monarch of the system is the Sun, round which all the planets revolve. These planets are eight in number, four of them from their general resemblance in many respects to our earth are called terrestrial planets; the other four, from their great size are called major planets. Their names, beginning with the one nearest the sun, are Mercury, Venus, the Earth, Mars—these are the terrestrial planets—Jupiter, Saturn, Uranus, and Neptune. The first thing to be noted about these is that they all revolve round the sun in nearly the same plane. Suppose we could rise above the solar system so that we were looking down at all the north poles of the planets, let us try to imagine what the appearance would be. Think of a clock face 13 feet in diameter with eight hands so fine as to be invisible. Mercury would be at the tip of the first hand, 1 inch long. The next hand, nearly 2 inches long, would have Venus at its end; then would come the Earth, just over $2\frac{1}{2}$ inches from the centre, followed by

Mars, almost	4 inches
Jupiter over	1 foot 1 inch
Saturn over	2 feet
Uranus over	4 feet, and lastly

Neptune, at the extreme limit of the face.

They would all be revolving in a direction opposite the usual movement of the hands of a clock. Now as to their rates of movement. In watching the clock let us hurry up our earth so that she goes once round in an hour instead of in a year. Then the times taken by the various members of our model would be as follows:

	Days	Hours	Mins.	Secs.
Mercury . . .	..	..	14	24
Venus	..	..	37	12
Earth	..	1	..	..
Mars	..	1	52	48
Jupiter	..	11	51	36
Saturn . . .	1	5	27	36
Uranus . . .	3	12	1	12
Neptune . . .	6	20	46	48

Not only do all the planets revolve round the sun in the same direction; they are also spinning round each on its own axis, and this rotation is in the same direction too—*i.e.* from west to east. It is as if a waltzer were "reversing," but going round the room in the usual direction. Further, all the planets but two, Mercury and Venus, have satellites, and these revolve round their respective planets, with exceptions to be mentioned later, in a similar direction.

Our illustration (Fig. 2) is an imperfect one in important respects. In the first place, with the scale we have adopted, the sun, which could comfortably swallow up all the planets and scarcely know the difference, would be so small that the tiniest pencil-dot would be ridiculously large. The sizes will be dealt with later.

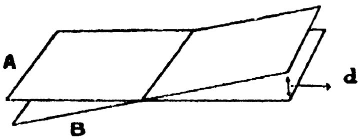


FIG. 2.

Secondly, although the planets have been represented as moving in the same plane, this is not quite the case. If two post cards are cut half through the middle they can be fitted together, as in diagram. Then if the earth is supposed to describe a circle along the surface of card A, the other planets will move along other cards, such as B. The deviation from the plane in which the earth moves—called the plane of the ecliptic—is greatest in the case of Mercury; in its case the distance, *d*, between the cards would be rather less than $\frac{3}{8}$ of an inch. If our model clock had a glass face, then to allow the planets free play there would have to be a space of nearly 10 inches between the actual face and the glass. Were the model a pocket one like a watch, then $\frac{1}{10}$ of an inch between the face and the glass would give ample room for the working of the whole system.

Paths of the Planets.—We have assumed that the system is a series of concentric circles, with the sun at the centre. But in reality the paths described by the planets are not circles at all, but ellipses. An ellipse is an easy figure to draw. Tie the two ends of a piece of thread together and pass the loop thus formed over two pins or drawing-pins fixed any convenient distance apart. Insert a pencil in the loop and stretch the thread tight. While the thread is kept tight the pencil will trace out an ellipse (Fig. 3). The greater the distance between the two pins the flatter is the figure, and on the other hand, the closer the pins are the more nearly will the figure correspond to a circle. The pins represent the foci of the ellipse, and the sun is at a focus, and not at the centre. The deviation from the circular is greatest in the case of Mercury, a good deal the greatest, and therefore the relative distance apart of the foci is also the greatest. In the figure we have been imagining, the sun ought not to be in the centre, but as in diagram

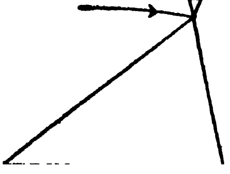


FIG. 3.

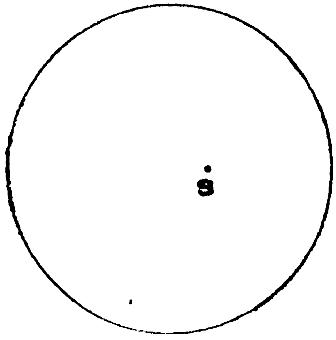


FIG. 4.

or rather, keeping the sun in the centre of our clock, the whole of Mercury's orbit ought to be shifted considerably to the left (Fig. 4).

The above figure is circular; all that has been done is to rectify the position of the sun. The true shape of the orbit is shown on a larger scale. Close examination will reveal that it is not circular (Fig. 5).

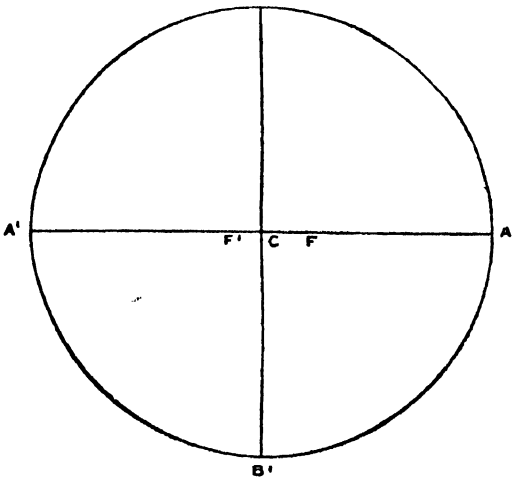


FIG. 5.

You will notice a considerable gap between Mars and Jupiter. If to each of the series of figures 0, 3, 6, 12, 24, 48, &c., the number 4 be added, the resultant series 4, 7, 10, 16, &c., will

represent fairly accurately the relative distances of the planets with the exception of Neptune, which is much too near. But there is no planet at the distance represented by the number 28. This has led astronomers in the past to suspect that there might be an undiscovered planet in the vacant space. A search of the heavens has revealed that in place of a single planet occupying this space there is a swarm of small bodies known as planetoids. It looks as if these bodies, during the formation of the solar system, had somehow failed to coalesce into a single planet. One of them, Eros, is of considerable interest. It describes an ellipse of great eccentricity—that is, its foci are very far apart, so much so that its path actually interlaces the path of Mars, and it therefore comes nearer the earth during part of its course than Mars does. This fact has proved valuable to astronomers in determining the distance of the sun from us, and the actual distances of the planets.

Sizes of the Planets.—We now come to the question of the sizes of the planets. First of all let us see what in round numbers their actual sizes are :

Planet	*Diameter*
Mercury . . .	2,750 miles
Venus . . .	7,800 „
Earth . . .	8,000 „
Mars . . .	4,350 „
Jupiter . . .	87,000 „
Saturn . . .	73,000 „
Uranus . . .	34,900 „
Neptune . . .	32,900 „
(Eros	probably about 20 miles)

These figures really convey little idea of the relative dimensions; the student is therefore advised to draw for himself circles representing the different planets. Take, say, $\frac{1}{10}$ of an inch to represent 1000 miles; then the diameter of the earth would be $\frac{8}{10}$ of an inch, Jupiter, the largest, would be $8\frac{7}{10}$ inches. If you haven't paper large enough to hold this you must alter your scale. The diameter of the sun is 866,500 miles, and you can estimate for yourself what size of a sheet you would require to contain the sun on this scale.

But there is a general tendency to estimate wrongly the volume of a sphere when its diameter is seen, and it is therefore advisable to deal, not with circles, but with actual objects. Let an orange, or a tennis ball, or a pill, or any convenient round object, stand for one of the planets, and find other objects corresponding to the other planets. It may help some to know that the diameter of a sphere is conveniently measured by placing it between two cubes, blocks of wood, cardboard boxes, or the like, and measuring the distance between the blocks. To get suitable spheres, it is a good plan to invade the nearest toy-shop and go over the stock of india-rubber balls. To show how easily one may go wrong from simply looking at the diameters, let us take the case of Mars and the earth. The diameter of Mars, you will see, is a little over half that of the earth. Now take a tennis ball to represent the earth, how will a golf ball do for Mars ? It is considerably too big. With the outer cover removed it is just about right. Mercury is on this scale a ball $\frac{7}{8}$ of an inch in diameter. Try if a marble will do. Will a football do for Neptune, just under 11 inches ? As for the sun, as it would be 24 feet in diameter it would require a hall to hold it. On the same scale the earth would be nearly $\frac{1}{2}$ a mile from the sun and the limits of the solar system would be nearly 14 miles away from the sun, that is, if Neptune is taken as the limit, which leaves out of account the possibility of discovering another planet beyond Neptune, and also ignores the comets which form part of the system, and which will be discussed later.

Now that a general idea of the solar system has been given, something must be said about the members of the system. And naturally we shall start with the earth, not only as being our abode, but because in discussing it we shall find out some of the principles which have led to the discovery of the facts that have been mentioned about the system generally.

THE EARTH

The original conception of the earth as flat was a natural one ; but even in very early times it came to be surmised that it was actually a globe. The absence of experimental proof and other causes led to this truth dropping into obscurity, and its re-emergence was one of the signs of the close of the Middle Ages. There are numerous familiar evidences against flatness, such as the manner in which ships disappear when sailing away from an observer, the circular shadow of the earth on the moon during an eclipse of the moon, the circular shape of the horizon when no irregularities obstruct the view, the fact that when three posts of equal height are placed in a line at distances a mile apart the middle one is seen to be eight inches above the others. Notice that it is no proof to say that ships have sailed round the world : they could just as easily do so if the ocean were a basin with the North Pole in the middle. The most complete and rigorous proof can be expressed in this way. When a traveller goes north by equal stages, the altitude of the Pole Star (or, to be correct, the Pole of the sky) increases by equal amounts; and when two travellers some distance apart go northwards keeping abreast of each other, they approach each other at a rate that can only be explained on the assumption that the earth is a sphere. The mathematical proof of this need not detain us here.

Both theory and experiment show that the

earth is not truly spherical, but is somewhat flattened at the poles.

The size of the earth is determined by measurement of lines running in uniform directions (Fig. 6). These lines are arcs of circles, and are measured by the method known as triangulation. To get the distance between A and B, a base line eight miles or so in length is measured with the

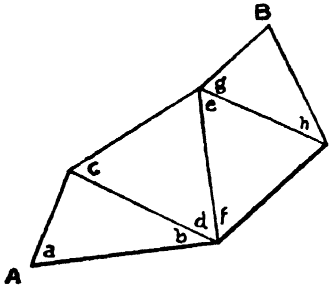


FIG. 6.

greatest care, and by measuring the angles *a*, *b*, &c., B is at last reached. Once the arc is known, the circumference of the circle can be found, and from this the diameter. The equatorial diameter has been found to be almost 7926 miles, and the polar diameter about 27 miles less. More exact measurements later show that there are minute deviations from accurate circular shape. It is interesting to know that on the accurate measurement of the original base lines depends the accuracy of all celestial measurements.

Mass of the Earth.—The next question that arises is, What is the mass of the earth? The best way in which to express the answer is to say how much heavier it is, bulk for bulk, than water. Obviously this is not an easy problem, and the method employed for its solution depends on the Law of Gravitation enunciated by Newton. This law states that "every particle in the universe attracts every other particle with a force that varies directly as the product of their masses and inversely as the square of their distance apart." The discovery of the law is Newton's greatest achievement. Only now are scientists beginning to think they are on the track of any explanation of it. It has been applied to the unravelling of the secrets of astronomy with marvellous success; and yet astronomers are beginning to suspect that even this law has not said the last word in the relations between bodies.

A general idea of two different methods employed to "weigh the earth" may now be given. Mathematical details would occupy us too long (Fig. 7). (1) When a plumb-line is freely suspended, the weight hangs vertically downwards under the attraction of gravity. But when this is done in the neighbourhood of a mountain, the line is deflected from the true vertical, because of the attraction exerted by the mountain. This deflection can be measured and the mass of the mountain estimated, and in

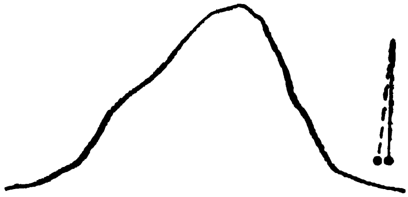


FIG. 7.

this way the relative attracting powers of the earth and the mountain can be found. The experiment has been done in the case of Schiehallion and other mountains.

(2) Weights A and B are counterpoised in a balance (Fig. 8). Then a mass of lead is introduced below the pan containing A. According to Newton's law, the extra mass below A will exert an extra pull on that pan of the balance, and A will appear heavier. If the lead be now introduced below the pan containing B, it in its turn

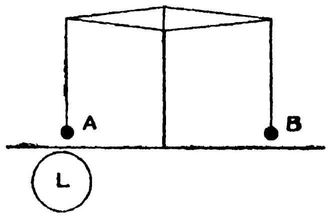


FIG. 8.

will appear the heavier. Thus the pull of the earth can be compared with the pull of the lead. It is obvious that so delicate an experiment as this is not the simple affair here described, and has demanded the greatest ingenuity to overcome the difficulties involved.

As a result of these and other methods the earth has been found to be 5·5 times as heavy as water. This is considerably heavier than the usual weight of the rocks of the crust of the earth. Either the interior of the globe is made up of intrinsically heavier material, or there is a great increase of density owing to the pressure to which the interior is subjected, or both factors may come into play.

Rotation of the Earth.—Anyone who has been in a steamboat leaving a pier must often have seen the pier to all appearance floating away from him. To all children in a train the telegraph poles seem to be rushing past, and even to more experienced people seated in a train at a station with another train on the line next them, it is sometimes a matter of uncertainty which train has started until they look at the platform. In the same way it was for long uncertain whether the sun, moon, and stars went round the earth or whether the earth was

spinning on its axis. The equatorial bulge of the earth and the flattening at the poles can only be explained on the assumption that the earth is rotating. The direction of the Trade Winds is also completely explained on the assumption of a rotating earth.

"Foucault's Pendulum" gives an experimental proof of rotation. Such a pendulum is easily made. It depends on the principle that when once a pendulum is set swinging it tends to continue swinging in the same plane. A bicycle ball, as used in the bearings, is soldered on to a brass wire shaped as in diagram. At the end of the wire a weight is fixed. The ball is supported on a glass slip. The weight is pulled aside and fixed in position by a thread (Fig. 9). When the thread is quite steady, it is

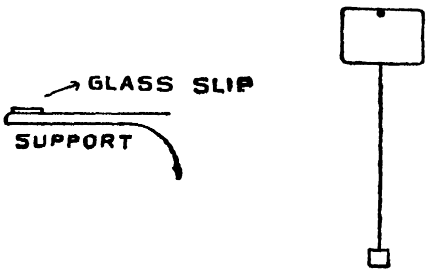


Fig. 9.

burned, and the pendulum is free to swing. The pendulum will appear to deviate steadily from its original position, but what is happening in reality is that the earth is steadily turning away beneath it.

Revolution of the Earth. — Long-continued observation of the planets only served to increase the difficulty of explaining their movements among the stars—*i.e.* their movements against the background of stars. Leaving out of account the ancient Greek astronomers, it is to Copernicus (died 1543) that we owe the true solution of the problem, for it was he who showed that the irregularities of motion could be best explained on the assumption that the sun and not the earth is the centre of the solar system. Later, Galileo showed the superiority of the Copernican theory over the geocentric theory of Ptolemy, which had held the field for about 1400 years; and about the same time Kepler enunciated his famous three laws of planetary motions, which were to be afterwards used by Newton in confirmation of his laws. The first law states the elliptical shape of the orbit of the planets. The second is best explained by a diagram, and deals with the rate of motion of every planet, for observation had shown that it does not move with uniform velocity in its orbit. The planet moves so as to cover equal areas, as in diagram (Fig. 10), in equal times. The third law says: "The squares of the periods of any two planets are to each other as the cubes of their distances from the sun." These are the facts as established by Kepler; it was left to Newton to provide an explanation of them.

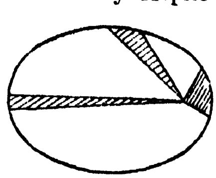


Fig. 10.

It was natural to assume that if the earth went round the sun, then the stars ought to show some displacement of position during the revolution. If you are going round a race-course, an outside object—a tree, for instance—may at one time be north-east, then due north, and again north-west. Similarly, if you fix the exact position of a star in spring, it may show some departure from that position in autumn. The ancients had been able to detect no such thing, and that was one of the great arguments against the revolution theory. But the invention of the telescope and the employment of more accurate methods of measurement might give a different result. So thought Bradley, the Astronomer-Royal of England, and in 1725 he set himself to the task. It is remarkable that though his attempt to prove the annual parallax of the stars, as it is called, was a total failure, he made another discovery which itself was a proof of the revolution of the earth. He discovered the phenomenon known as the aberration of light. Before explaining this it may be well to say that with increased power of making delicate angular measurements the annual parallax has now been established in the case of a number of stars.

When you are walking in a downpour of rain, if the rain is falling straight downwards, you have to hold your sheltering umbrella a little in advance of you, and the faster you walk the more you have to incline your umbrella. For your motion makes the rain, as far as you are concerned, seem to come in a slanting direction. Similarly, one sees that on a quickly moving train the rain-drops describe a slanting course down the window-pane. Other examples of the same kind will readily occur to you. The phenomenon Bradley discovered was something of this nature. To see a star, you must look along the rays of light in the direction in which they come to you. Now, if you consider a particular star, for simplicity in the same plane as the earth's path round the sun, it is evident that, if the earth goes round the sun, it will at one particular point of its motion be going straight towards the star, after a quarter of a revolution it will be cutting right across the path made by the star's rays, another quarter revolution and it is going straight away from the star, still another quarter revolution and it is again cutting across the path of the rays, but this time in the opposite direction. In the first and third cases there will be no apparent slanting of the star's rays and the star will be seen in its correct posi-

tion, but in the second and fourth cases there will be a slanting of the rays, the telescope will have to be inclined forward, as the umbrella has to be; but as the earth is going in exactly opposite directions in the two cases, the telescope will be inclined accordingly in exactly opposite directions. This is the discovery made by Bradley. The aberration of light, or the deviation from the true direction, is a very small quantity, the angular displacement is less than twenty-one seconds; and when you consider that a second is the sixtieth part of a minute and a minute the sixtieth part of a degree, and when you look at the size of a degree, on a protractor, you can form some idea of the delicacy of the measurement, though, as astronomical measurements go, it is quite large. The parallax of the stars, for example, already referred to, is in no case so much as one second.

Precession and Nutation.—If we imagine the earth floating round the sun on a perfectly smooth sea, then, as is well known, the North Pole of the earth will not be pointing directly upwards, but is tilted at an angle of $23\frac{1}{2}°$; half the equator is therefore out of the water and the other half submerged. From this we get the phenomena of the seasons. The planes of the equator and of the ecliptic intersect in a straight line. These planes may be represented by two post cards, just as we have done before in the case of the planes of the planets. Twice in the year, at the spring and autumn equinox, the sun is situated on the line of intersection of the planes. At the spring equinox the continuation of this line from the earth through the sun to the star takes you to the First Point of Aries; at the autumn equinox the line takes you to the constellation Libra.

But owing to the bulge at the equator the moon and the sun both exert an extra pull on the equator and attempt to pull over the axis of the earth, so that it is no longer tilted. The actual result is to make the axis of the earth describe a circular motion, such as a spinning top does before it becomes absolutely steady. This means that though the North Pole of the earth at present points nearly to the Pole Star, it has not always done so nor will always do so. It points in succession to different points in the heavens, describing a circle which takes about 25,000 years to complete. During this time the equinoctial line is moving westwards and the spring equinox will occur, not when the sun is at the First Point of Aries, but when the sun is at the other Signs of the Zodiac—Pisces, Aquarius, and the rest. Indeed the sun is now in Pisces, though the term First Point of Aries is retained. This movement is called the Precession of the Equinoxes.

There is still another movement due to the attraction of the moon on the equatorial bulge, called nutation, completed in about nineteen years. It is best seen in a figure (Fig. 11).

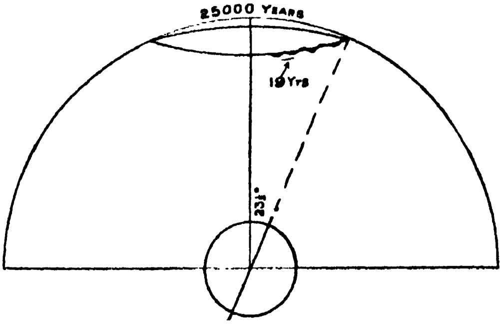


Fig. 11.

All this requires the exercise of a good deal of imagination in order to form a picture of what is taking place. Astronomical explanations and diagrams are notoriously difficult of comprehension unless when so supplemented.

Distance of the Earth from the Sun.—This problem has been attacked in several ways. (1) Once the density of the earth and its period of revolution are known, it is possible to calculate the distance. (2) It can be found from observing the eclipses of Jupiter's moons. This observation was first used to find the velocity of light; but the velocity of light can be found now with great accuracy by laboratory experiments. The principle is this: The exact moment when one of Jupiter's moons passes behind the planet is known. But if the occultation is observed when the earth is at the two positions of its orbit shown in the figure (Fig. 12), there is found to be a considerable discrepancy.

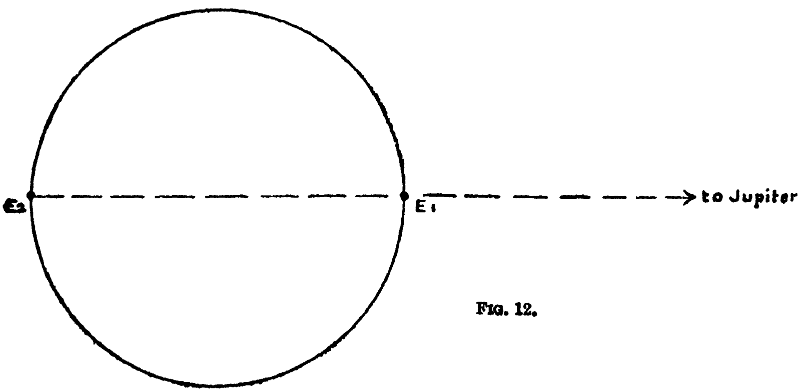


Fig. 12.

This is due to the time the light takes in passing over the space between E_1 and E_2. Since the velocity of light is known, it is easy to calculate the diameter of the earth's orbit. (3) The velocity of light can be used in another way. The aberration of light causes the light from a star to appear to come to us along the line XB instead of along the line XA (Fig. 13). XA represents the velocity of light, the angle X can be measured, and thus the velocity of the earth represented by the line BA is found. From this the total length of the orbit, and therefore the distance from the sun, can be calculated.

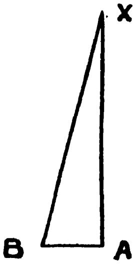


FIG. 13.

(4) These are all, as will be observed, indirect methods. But one direct method has been employed with great success. From Kepler's third law it is quite easy to find the relative distances of the planets. Thus it is comparatively simple to make a model of the solar system with all the distances relatively correct; the trouble has been to find the true scale. It is obvious that if any one of the distances can be found, the problem is solved. Attempts were made to find the distance of Venus, and of Mars, but in these cases uncertainties arose. The planetoid Eros, which actually comes nearer us at one part of its course than Mars ever does, has been used with remarkably successful results. The working out of this method occupied about ten years, but the principle is simple (Fig. 14). It consists in observing Eros from two stations

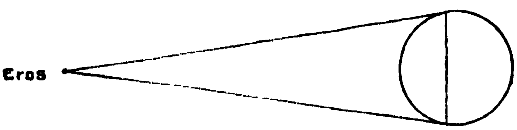


FIG. 14.

on the earth as far apart as possible. (Of course in reality a great many more than two stations were used.) The distance between the stations is known, and the observations of the position of Eros give the angles of the triangle. Therefore the triangle is fully determined, and therefore the distance of Eros is known. From this the scale of the solar system is also known. By this method the mean distance of the sun is found to be 92,830,000 miles.

THE MOON

As our nearest neighbour in space and the most brilliant object in the heavens at night, the moon has naturally received a great amount of attention in all ages. The results of this observation can be given, but it is as well for the student to make as many of these observations for himself as he can. A good many can be made without the use of a telescope. For instance, everyone knows that the moon rises somewhere in the east and sets in the west, but the student ought for himself to note whether it passes a certain point—the meridian, say—at the same time every night. He ought also to note its position relative to the stars. If, for instance, a bright star (not a planet) is seen fairly near it, one night's observation will settle whether the moon and star keep the same relative position all the time. He could observe the difference in time of rising on successive nights and discover whether this difference is a constant quantity. He could measure the height to which the moon rises when it is due south and find out if this remains constant during the month, and during the year. Nor will it be difficult to see the relation between the phases of the moon and the position of the sun. By observation of the crescent moon he can see whether the tips of the crescent ever point to the sun and explain the result of his observation. The markings of the lunar surface should be observed to make sure that the moon always presents the same face to the earth. This means that the moon makes one rotation round its own axis in exactly the same time that it makes one revolution round the earth. Some people have a difficulty in seeing that it rotates at all. But if it did not rotate, every part in succession would be visible from the earth, just as from the hub of the Great Wheel at Earl's Court every part of any one of the cars could be seen as the car revolved.

Angular Diameter of the Moon.—The student might also make an attempt to discover the angular diameter of the moon. Roughly it is half a degree, and with a theodolite it could be measured fairly accurately, though by no means with the accuracy needed for astronomical work; but at first one wants to have a general idea of angular measurement, and not to attempt anything accurate. Even without a theodolite it is possible to see what is meant by the statement that the diameter of the moon is half a degree. Wet a piece of confetti and stick it on a sheet of glass. Hold it up to the full moon at such a distance that the moon is just covered. Get someone to measure with a measuring-tape the distance from your eye to the glass. Transfer the dimensions to a sheet of paper thus (Fig. 15):

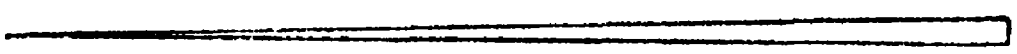


FIG. 15.

You can then measure, or try to measure, the angle. Or get the sine of the angle by dividing the diameter of the circle by the distance from the eye. If you look up your result in a table of sines you can find the angle. The same thing can be done by punching a hole in a sheet of

cardboard like the hole punched in tramway tickets and holding it up to the moon. If you use too large a hole, the distance from the eye will be too great to transfer to paper afterwards.

The moon is one of the most satisfactory celestial objects to look at with a small telescope or with a field-glass. On first seeing the moon in this way certain points immediately strike the observer. He sees that it actually is a ball. It appears nearer to him. The details appear clearer than when seen with the naked eye. But it does not appear at all larger. But if, while the one eye is at the telescope, he opens the other eye, he will see at once how very much bigger the magnified image really is.

Surface of the Moon.—The moon is best seen through a telescope when it is about the first or third quarter—*i.e.* about half moon. It is then that details are most clearly shown up. Scottish students at least will understand what is meant by saying that the general appearance of the surface is exceedingly like that of the surface of a pot of boiling porridge. It is covered with great numbers of what look like burst bubbles, large and small, sometimes one within the other, sometimes overlapping. The general explanation is that these are extinct volcanoes, though this explanation is not universally accepted. When the moon is about half full, the shadows cast by the walls of the craters are easily seen; so are the shadows cast by the mountain ranges. Some of the craters have a central peak. The diameter of a number of these craters has been measured; some are more than 100 miles. We have nothing on earth comparable in size to these.

When the moon is full, no one can fail to see, near the top if the telescope is the usual astronomical one which inverts the object, near the bottom in a field-glass, a crater from which radiate a number of bright lines, called rays. It looks as if one were looking at the pole of the moon and these were meridian lines. This is the crater Tycho, so named in honour of a celebrated Danish astronomer. Other rays are to be seen radiating from other craters. There are no analogous markings on the surface of the earth, and the explanation of these rays is by no means certain. Other long lines are called rills, some straight, others curved. They seem to be cracks in the surface of the moon, extending for 150 miles sometimes. These form another puzzling feature in the topography of the moon.

How is it known that the moon has no atmosphere? For one thing, if there were, the detail of the surface would sometimes be obscured, which it never is. For another thing, when the moon is not full, part of the face turned towards the earth is in full sunlight, part gets none. Were there an atmosphere, there would be a twilight effect between these two parts, but the sunlit edge, the "terminator," is always sharply defined. And when a star is occulted by the moon, there is no gradual dimming of the brightness of the star as the moon begins to pass between it and us, the disappearance of the star is instantaneous. Then what has come of its atmosphere? Perhaps it never had one. It may have combined with the material of the moon's crust. But most probably it has simply escaped from the moon. As we know, our atmosphere is bound to the earth by the attraction of gravity. But the attraction of gravity in the case of the moon is very much less than in the case of the earth, and any particle of gas which happened to have a certain relatively small velocity away from the moon would be able to escape.

Attraction of the Moon.—If it is asked, why is the attraction of the moon less than the attraction of the earth, the answer is that the attracting power, according to the law of gravitation, depends on mass, and the mass of the moon is very much less than that of the earth. This leads us to take up next the question of the size of the moon, its mass, its distance from the earth. The distance from the earth is got by a set of observations such as were made in the case of Eros already described. The distance is in round numbers 240,000 miles. Once the distance is known and the angular diameter is also known, the diameter in miles can be found. It is 2163 miles, rather over a quarter that of the earth. No other planet has a satellite anywhere near a quarter of its own diameter. If the earth is represented by a tennis ball as before, then the moon would be about $\frac{5}{8}$ of an inch in diameter, and would be distant from the earth between 6 and 7 feet. It is easy to get a marble of about the right size for the moon. The mass of the moon has not been so easy to discover. For the solution of the problem the law of gravitation is brought in. It is commonly said that the moon revolves round the earth; in reality the earth and the moon revolve round their common centre of gravity. If a pin is put through a straw almost at the end, the earth may be supposed to be at the near end and the moon at the far-off end. The whole can then be rotated round the pin. The centre of gravity of the system is so near the centre of the earth that it is some distance under the surface. But this monthly revolution round the common centre of gravity can be measured; it has been measured in observations of the sun and in observing the planetoid Eros; and the position of this centre of gravity depends on the mass of the earth and that of the moon. In round numbers, the earth is eighty times as heavy as the moon. Bulk for bulk, the moon is 3·4 times as heavy as water. And the attraction of gravity at its surface is one-sixth that at the surface of the earth. A person who could clear a five-foot bar here could jump 30 feet high on the moon.

As has been said, the moon exerts an attraction on the earth just as the earth attracts the moon. To this attraction, and in a less degree to the attraction of the sun, the phenomena of the tides are due. For the fluid hydrosphere yields to the attraction in a way that is impossible with the solid earth, and a tidal wave passes round the earth twice a day. There are really two tidal waves at opposite sides of the globe, and when we say that the waves pass round the earth, the true state of matters is that the earth is rotating, but the attraction of the moon tends to keep the water from rotating, and therefore the heaped-up waters appear to travel round the globe in a westerly direction. The action is much too complicated to go into any further here. But it is to be remarked that the friction of the tides has a retarding influence on the rotation of the globe and tends to lengthen the day. Other influences, it may be added, tend to shorten the day, but on the whole it seems that our day is lengthening by a small amount as the centuries roll on.

Similarly, the action of the earth on the moon, when the moon was in a more fluid condition than at present, has been to raise tides, much more powerful in effect than the tides raised by the moon on the earth, and the friction of these tides has been so great as to slow down the rotation of the moon until it always presented the same face to the earth.

The Harvest Moon.—In September, as the twilight is deepening the full moon pours a flood of light over the earth. The moon on the average is about fifty minutes later in rising each night, but in this month it rises night after night at very nearly the same time, taking perhaps a week to be the usual fifty minutes behind the first rising. This has been of great advantage in the old days when every minute of light was precious for the ingathering of the harvest. This phenomenon may serve as a peg on which to hang the explanation of some points in connection with the moon's and sun's motion. We shall look at it from the standpoint of the *apparent* motion of the moon and sun.

Let us imagine that it is possible to see the moon and stars, even when the sun is shining. Then we have to think of the heavens as they were imagined in ancient times, as a hollow sphere with ourselves situated at the centre. This sphere is in steady motion round two points called the celestial poles, one of these being close to the Pole Star. The stars near the poles describe small circles, as we look farther and farther away from the poles the stars are describing larger and larger circles. Midway between the poles is the largest circle of all. This is the celestial equator. If the North and South Poles and the plane of the equator of the earth were extended far enough they would coincide with their celestial namesakes. If the equator could be marked by a line in the heavens it would never alter its position any more than the poles do. Every point in the heavens 90° from the pole is on the equator. The whole of the equator cannot be seen at any one time (except to an observer standing at one of the poles of the earth).

Now suppose yourself facing east on the 21st of March, and waiting for the sun to rise. It will rise exactly on the celestial equator. Let us imagine you can see the moon rise at exactly the same place at exactly the same time. Also let us fix on a star close to them as they rise. They will sweep across the heavens and set in the west. Again wait for their rising next morning. First the star will rise, four minutes later the sun will rise, and last the moon. But now neither the sun nor the moon is on the equator. We can easily mark the new positions, and we shall discover that both sun and moon, besides describing a daily circle round the earth, are tracing a path among the stars. The sun's path is a great circle, and in a year it is back to its original position. When only six months have passed it is again on the equator at a point opposite the first one. The moon's path amongst the stars is almost the same as the sun's, but it completes its journey among the stars in a month. It crosses the equator again in a fortnight. In a year the moon is at least twelve times close to the sun, and as often it is as far from the sun as it can get. The path the sun traces amongst the stars is called the ecliptic, and the moon's does not deviate much from it. We can easily suppose a line tracing out the ecliptic on the heavens as the equator was traced out. This line will rotate round the earth every day.

Now if we return to the 21st of March the relation between the equator and the ecliptic during the day—at 6 A.M., at noon, and at 6 P.M. —will be as shown in the diagrams. You will be able to follow the figures better if you take a pair of the spring trouser-clips used by cyclists, or make two circles to fit each other out of stout paper and pull them apart as shown (Fig. 16).

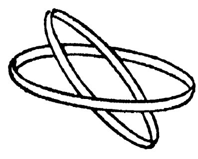


FIG. 16.

Then, if the combination is rolled round, the relative motion of equator and ecliptic can be followed with ease (Fig. 17).

The important point to note with regard to these figures representing one day's motion is that in the morning the ecliptic is below, *i.e.* to the south of the equator, in the evening it is to the north. It is also as well to reiterate that the dotted line —the ecliptic—is not the daily path of the sun; when the sun rises or sets every day it is only a little bit farther along that line, in a backward direction.

Consider now the state of affairs in a fortnight's time. The sun has moved only a small way along the ecliptic, and at sunset, therefore, is not far from the right-hand side of the third

FIG. 17.

figure. But the moon has moved so far back along the dotted line that it is now at the left-hand side of the figure. It is opposite the sun, and therefore full. Let us look at the moonrise on two consecutive nights (Fig. 18). We must face the eastern horizon, and we are now looking at the left-hand side of the third figure. On the first night it is just on the horizon, but on the second it has moved back along its path and at the same time of night as before it has some distance still to go before it reaches the horizon, as shown.

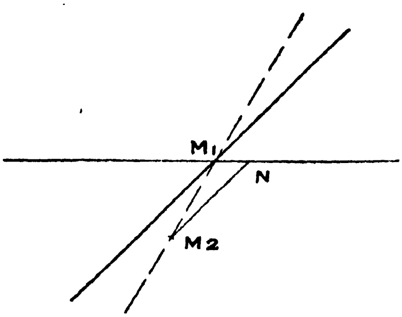


FIG. 18.

Next, and finally, consider the state of affairs in six months' time, *i.e.* in September. The sun, which at sunrise on the first occasion was at the left-hand point of the first figure, has now travelled so far along the ecliptic as to be at the second point of intersection of the ecliptic and

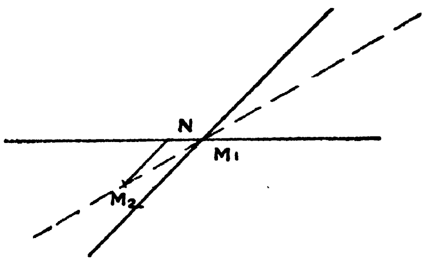


FIG. 19.

the equator, but this time at sunrise it is at the left-hand point of the third figure, and at sunset it is at the right-hand point of the first figure. The September full moon is of course opposite the sun, and is accordingly rising when the sun is setting. It rises at the left-hand point of the first figure. Once more let us look at the moonrise on two consecutive nights, facing the eastern horizon and looking at the left-hand side of the first figure. As before, on the first night it is just on the horizon, but on the second (Fig. 19.) it has moved back along its path and it has some distance to go before it reaches the horizon. It will be noted that though the distance M_1M_2 is the same in both cases yet the distance the moon has to rise (M_2N) is very much smaller in the second case. It is the small angle that the moon's orbit makes with the horizon that is the cause of the harvest moon.

This may appear a too meticulous examination of a somewhat unimportant phenomenon; but it has been introduced purposely to induce the student to think out, and to visualise, as far as possible, the different movements of the heavenly bodies. He will probably find it fatiguing work at first, but his reward will be the greater when the moment of comprehension comes.

The Spectroscope.—Before going on to deal with the sun it is necessary to indicate how the spectroscope has, within the lifetime of men still alive, revealed to us the secrets of the constitution of the universe in a way that marks a new epoch in astronomy. Only the briefest account is possible here.

We are all familiar with the rainbow, and know that the colours of the rainbow—red, orange, yellow, green, blue, indigo, violet—are due to the breaking-up of the white light of the sun into its constituent elements. We all know also that the colours of the rainbow can be produced by passing sunlight through a triangular prism of glass. The same colours are seen when a drop of oil from a motor-car spreads out into a thin film on a pool of water. They can also be produced by passing light through a "diffraction grating" consisting of thousands of lines per inch ruled on glass, or by reflecting it from a grating ruled on speculum metal. These last methods are commonly used. A continuous spectrum like the rainbow is produced by the light from white-hot solids or liquids, or from strongly heated gases if these are under great pressure.

But the spectrum of incandescent gases under ordinary conditions is quite different, and this applies to all substances in the gaseous state even though they are ordinarily solids in their natural condition on the earth. Thus, if the wick of a spirit-lamp is covered with common salt the flame of the lamp is intensely yellow. If this flame is looked at through a spectroscope, then instead of seeing the whole sequence of colours—red, orange, etc.—only one bright

line will appear, really an image of the flame in the yellow part of the spectrum. When the light passes through a slit the image of the slit will be shown, and if the slit is narrow enough two images and not one will be seen, which would overlap if the slit were wider. Those two lines are always in the same part of the spectrum, and are always found when sodium is present. In this case of course the sodium is supplied by the common salt. These are called the lines D_1 and D_2.

When the spectroscope is directed to a vacuum tube containing a trace of hydrogen through which an electric spark is passing four lines are seen, one red, one between the green and blue, one indigo, and one violet.

The incandescent vapour of iron gives more than 2000 bright lines, well distributed over the whole range of the spectrum. Note that this applies only to the vapour of iron. Iron when it is white-hot gives a continuous spectrum, and not a line spectrum. In the same and other ways the line spectra of various terrestrial substances can be examined. Photography has been applied to spectrum analysis with conspicuous success. Naturally in a photograph these lines are recognised not by their colours but only by their position in the spectrum.

The sun gives a continuous spectrum; therefore it is a white-hot solid or liquid or a gas under great pressure. But its spectrum is crossed by a great number of dark lines, called the Fraunhofer lines after the man who first made a serious examination of them. It is not much more than fifty years since the explanation of these, which has given rise to the new science of Astrophysics, was discovered.

The Sun's Spectrum.—Fraunhofer observed that two of the dark lines were apparently in the position occupied by the bright lines given by sodium. Kirchhoff, years later, in 1859, found that if ordinary daylight, which gives the same spectrum as the sun, is passed through a sodium flame before being examined in a spectroscope, then the dark lines are replaced by bright lines. This showed that there is an exact correspondence between their positions. But he found that if a sodium flame is interposed between the sun and the spectroscope the lines are only intensified in their darkness. Next he found that if a sodium flame is interposed between a limelight and the continuous spectrum it gives, then two dark lines appear in this spectrum in the sodium position. It was thus established that a glowing gas which has the power of giving a bright-line spectrum has also the power of intercepting those lines in a continuous spectrum. The sodium spectrum led the way in this discovery, but it has been established in all cases. In this manner it has been shown that surrounding the "photosphere" of the sun, which is the part giving a continuous spectrum, is a "reversing layer" of glowing gas, containing not only sodium, but also iron, hydrogen, and numerous other terrestrial elements. One element is of interest, inasmuch as the solar spectrum revealed its existence in the sun before it was discovered on the earth. Its presence was indicated by a line in the neighbourhood of the sodium lines, a line which no laboratory work with the terrestrial elements could reproduce. As belonging to the sun, it was called helium, the element which since its discovery on the earth has done so much to advance the knowledge of the structure of matter.

This reversing layer comes between us and the enormously brighter photosphere, but just at the edge of the sun there is no background of brighter light, and during eclipses of the sun there is an instant or two when the light of the sun has been cut off by the moon, and when the reversing layer is not yet hidden. At such a moment the dark lines of the spectrum suddenly flash out as bright lines. The time during which this flash spectrum lasts enables the thickness of the layer to be estimated. It is from five to six hundred miles thick.

The spectroscope has been of inestimable service in other directions besides in studying the sun, but these must be left till a later point.

THE SUN

To view the sun with the naked eye a smoked or coloured glass is essential. Burning camphor supplies a convenient method of smoking glass. But except during eclipses it is of little value to try any naked-eye work. Occasionally a sun-spot may be seen without the use of a telescope, but nothing else can be done, except to observe the daily and annual motions of the sun. With a small telescope a fair amount can be observed. The observations are best conducted by focussing the image of the sun on to a sheet of paper, as in sketch. The cardboard surrounding the telescope is to enable the sun's image to be viewed in the midst of a shadow. A very short observation will show that the image is drifting across the paper, and the telescope must be moved every now and then to accommodate it to the new position. It is advisable to draw a circle on the sheet of paper just large enough to hold the image, and to draw two diameters at right angles to each other. If now one of these lines is made to point in the direction that the imagine is moving, then you have fixed the east-and-west direction, and the other line gives the north-and-south direction. The chances are that you will see one or more spots on the sun. Their position ought to be marked, and if they are of any size their shape drawn (Fig. 20). If next day you repeat the process of getting the cross lines into their correct position, you will observe that the sun-spots are not in their former place. They are being carried round the sun in

the course of its rotation. Observations for a day or two will show you that the axis of rotation is inclined to the north-and-south line drawn on the paper. Prolonged examination of sun-spots has shown that the sun rotates on its axis

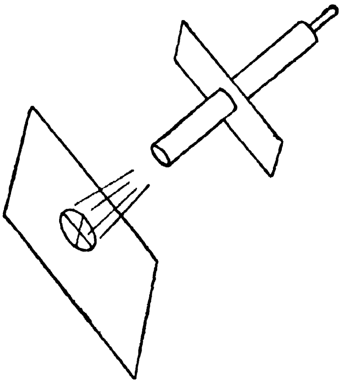


FIG. 20.

in about twenty-five days, but the curious result has been obtained that it is moving faster near its equator than it does in higher latitudes, thus proving that it is not a rigid body like the earth.

It is quite possible to see that the spots are not permanent features. They can be watched as they appear, as they change their form as they disappear. They evidently obey certain laws, though we are still in the dark as to the explanation of these. They attain a maximum every eleven years, nearly, and there is no doubt that magnetic storms on the earth have some close, unknown relation with sun-spot activity. Other solar phenomena are connected with the spots. As the spots are relatively dark parts of the surface, so there are relatively bright parts, called faculæ, and these increase in number as the spots increase. Then outside the reversing layer there is a narrow belt of crimson light known as the chromosphere, which is only visible during total eclipse. From the chromosphere every now and then prominences shoot out with great rapidity, sometimes five or six hundred miles a second, to a distance of perhaps 300,000 miles. Nowadays, by means of the spectroscope, the prominences can be seen at any time. It is found that these evidences of violent activity vary as the sun-spots do. Beyond the chromosphere is the corona, a halo of pearly light extending sometimes for millions of miles. This is visible only during total eclipse, and has never been detected at any other time. But observers have remarked that the shape of the corona is distinctly different at times of sun-spot maximum from its shape at sun-spot minima.

The chromosphere consists of glowing gas; the spectroscope shows the presence of hydrogen, helium, and calcium chiefly. Often the materials of the photosphere burst their way through the "reversing layer" into the chromosphere, and then some of the dark Fraunhofer lines flash out for a time as bright lines.

The corona apparently consists of particles which reflect the sunlight, for the Fraunhofer lines are to be found. But the spectroscope tells us there must be also incandescent solid or liquid particles. Lastly, there is present a gas giving a bright-line spectrum. This gas is unknown on the earth, and is called coronium. What keeps the corona from falling towards the sun under the force of gravity? Recently an approach at least to an answer has been found. It is now known that light exerts a pressure on dust particles if only they are small enough; and probably the corona consists of particles of a size which enables light from the sun to drive them out into space.

Evolution of Solar System.—There was for some time a great controversy between geologists and astronomers as to the evolution of the solar system. It arose in this way. The sun's heat was supposed by astronomers to be mainly produced by contraction, and by mathematical calculation they concluded that the sun has been supplying the earth with heat for twenty million years. This was no use to the geologists. They demanded a hundred million years. So the matter stood till the discovery of radium, and with it the discovery that the atom contains imprisoned an incalculable amount of energy, which in radium we see in the process of being set free. This has settled the problem. Contraction is not the sole, perhaps not the main, source of the energy the sun gives forth as heat, and the promisses of the mathematicians were wrong. One other source of heat may be mentioned. The sun may be gaining heat from the fall into it of matter from the outside in the form of meteorites. We have all seen for ourselves the amount of heat generated by meteorites—falling stars—when they enter our atmosphere. How much the sun may gain in this way is quite unknown.

An interesting proof of the sun's rotation ought to be given, as we shall meet with the principle again. When a train is approaching, the whistle of the engine is of a higher pitch than when it is stationary; when the train has passed and is now receding the whistle at once is lower in pitch. In the first case the motion of the train crowds the waves of sound more closely together; in the second the sound waves are lengthened out. A similar result takes place with light waves. Without going into detail, the result may be mentioned. When the source of light is advancing towards us the lines of the spectrum are shifted slightly towards the violet end; when the source is receding the lines are shifted towards the red end. Now, as the sun rotates one limb is approaching us, the other is

receding. Applying the spectroscope first to one limb and then to the other, the shift of the lines is easily seen, and from the amount of shift the rate can be calculated. The method is delicate enough to show the greater velocity of the sun in the equatorial region.

Eclipses.—The essential difference between solar and lunar eclipses depends on the fact that the sun shines by its own light, while the moon shines by reflected light. The sun therefore is eclipsed only when the moon comes between it and the earth and shuts off its light from us. The moon is eclipsed when the earth comes between it and the sun and keeps the sun from shining on it. When the earth's shadow sweeps over the moon every one on the earth who can see the moon can see its eclipse. But when the sun is eclipsed very few have an opportunity of seeing it, for the shadow cast by the moon is a comparatively small dot on the earth's surface, which sweeps in a long line across the earth. The position for lunar and for solar eclipses is shown in the diagrams (Fig. 21).

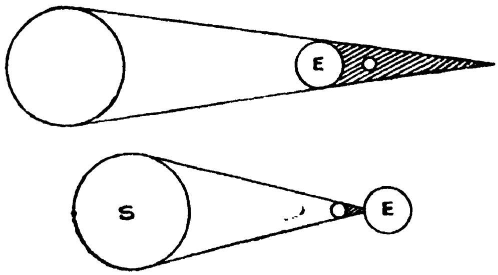


FIG. 21.

It is because the moon does not revolve round the earth exactly in the plane of the ecliptic that there is not an eclipse of each kind every month. If we imagine the earth as floating round the sun, then its shadow sweeps round with it on the surface. But at most full moons the moon is either a little above or a little below the surface, and so escapes the shadow. In the same way at new moon the moon is either too high or too low to come between us and the sun. Not till 1927 will there be another total eclipse of the sun visible in this country. There are always two eclipses of the sun every year, and there may be as many as four, visible in some parts of the globe. There are never more than two lunar eclipses every year, and there may be none. Eclipses of the sun may be annular, when the moon fails to cover the sun completely and leaves a ring of bright light. In that case the shadow of the moon is not long enough to reach the earth, and the position is as in figure (Fig. 22).

Total eclipses of the sun are of great interest and value to astronomers, the most out-of-the-way places are visited in order to study them, and elaborate preparations are made to make full use of the precious time of totality, never so much as eight minutes at the most. It is only then that the corona is ever visible to

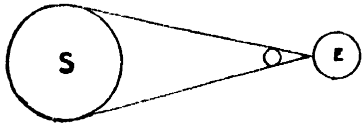


FIG. 22.

mortal eyes. Observers of total eclipses agree that the spectacle is one of the most impressive sights that can be seen.

THE PLANETS

The further study of the individual planets need not detain us long. Mercury and Venus, the inferior planets—*i.e.* the planets between the earth and the sun—can never be seen so far from the sun as the superior planets. They show changes of phase as the moon does. Neither of them has any accompanying satellite. Mercury is a difficult object to see even at the best, being always in the glow preceding sunrise or succeeding sunset, but when it is seen it is a beautiful object. Most daily papers in their monthly astronomical notes tell when it is best to be seen.

Venus.—The beautiful sight afforded by Venus when it is an evening star awakens the admiration of even the most ignorant observers. As a telescopic object it is rather unsatisfactory. It becomes an evening star every eighteen months or so, and remains so for three or four months.

Mercury always presents the same face to the sun; the same is probably true of Venus, but the latter planet has so dense a cloud-laden atmosphere that its period of rotation is doubtful, some astronomers holding that its rate of rotation is much the same as that of the earth.

Mars.—The planet that is the subject of most controversy is Mars, and the great question is: Is Mars inhabited? The problem of life in other worlds than ours naturally exerts the strongest fascination on the mind of man, and probably there is a more or less unconscious bias in the case of most people, which leads them to accept proofs which are far from rigorous, and reject evidence to the contrary. Most people feel a sensible disappointment on learning that the majority of astronomers hold, to put it at its lowest, that those who maintain that there is life on Mars have up till now failed to prove their case. What are the facts on which the case rests? On the surface of Mars may be seen two white polar caps, which increase in size in winter and decrease in summer. Now, as these decrease, long straight lines appear on the surface covering the whole of the planet like a network. These are supposed to be lines of

vegetation springing up along certain artificial channels. Schiaparelli was the first to see them, and they have been investigated for years by Lowell, who has found amongst other things that some of these canals are double. It seems to be generally accepted now that these "canals" do exist, in spite of the difficulty nearly every observer has in seeing them. Lowell's theory is that in the course of ages the water supply of the planet has been diminishing, and that the canals have been constructed by the Martians to conserve and make the best use of the remaining water supply.

Let us look at a few of the objections to this theory. It is a pure assumption that the polar caps are composed of water at all. Many hold that the temperature of Mars is so low that the caps are composed of solid carbonic acid gas. Even if it is water, its rate of appearance and disappearance suggests that it is a mere coating of hoar frost, unable to supply any quantity of water. Then why are the canals so straight? Nothing that we have on earth would suggest that there was any sense in such a gigantic engineering feat. As has already been mentioned, there are straight lines on the moon that no one can explain, yet no one has yet suggested that they are due to the action of an intelligent agency. Then it is said that the Martians are maintaining a fight against a disappearing supply of water. This is another pure assumption. It is known, moreover, that the atmosphere of Mars is exceedingly rare, so rare as to make the development of any form of higher life most unlikely. And all indications point to the fact that it is exposed to extreme cold such as would probably be fatal to intelligent life. It is safe to conclude that the problem is still unsolved.

The "moonless Mars" of the poets is now known to have two tiny moons, both revolving from west to east, but the inner revolves so rapidly that the inhabitants, if any, will see it rise in the west and set in the east twice every night.

Jupiter, the giant planet, is marked by broad parallel bands, whose detail is constantly changing. This has led to the supposition that they are great cloud formations. One other marking is of interest, the "great red spot," the most permanent of many red spots. Observation has shown that Jupiter rotates more rapidly near the equator than in higher latitudes. The planet is apparently very hot, and is probably largely gaseous near the surface. It has therefore a long way to go before it reaches the condition of the earth.

Four of its moons were discovered by Galileo, and extremely sharp eyes can sometimes detect them without optical aid. Eight moons are now known, and a ninth is said to have been discovered by photography this year. One is of great interest, inasmuch as instead of moving from west to east in the manner characteristic of members of the solar system, it has a retrograde motion.

Saturn.—Anyone who has been privileged to see Saturn through a large telescope has seen one of the most remarkable objects in the heavens. For Saturn is surrounded by a broad ring system in the plane of its equator. The inside ring is the crape ring, followed by a bright ring; then comes a division, and an outer bright ring. The spectroscope has shown that the inner parts move faster than the outer. This system consists of swarms of solid particles unconnected with each other.

Saturn has in addition nine satellites, one of which has a retrograde movement.

Uranus was discovered in 1781, this being the first discovery of the kind since ancient times. It has four satellites, and the remarkable thing about these is that they do not revolve in or near the plane of the planet's orbit, but at approximately right angles to it.

Students of the motion of Uranus found that, using all the data at their command, they could not account for its path. This led them to suspect some disturbing agency, perhaps a planet outside it. Adams in England, and Leverrier in France, set themselves to discover where such a planet would be. Working quite independently, they fixed on the same place; and when that spot was examined, there was the planet **Neptune.** This planet has not yet completed half its course round the sun since its discovery. It has one satellite, highly inclined to the plane of the ecliptic, and retrograde in its motion.

Comparatively little is known of the two last planets, they are so distant from us. It is thought by some that there may be a still more distant planet, but so far all efforts to find it have failed.

Comets and Meteors.—Most people are familiar with the traditional appearance of a comet, the bright head with a central nucleus, and the long tail streaming out from it. Few comets, however, are spectacular objects; even Halley's comet, looked for so eagerly, at its reappearance in 1910 was a great disappointment to most. The important point about the tail is that it always points away from the sun. It has been conjectured that it is driven off by electrical repulsion, or by light pressure; but the whole problem is very obscure, and astronomers adopt a non-committal attitude at present.

The matter of which comets are composed, as shown by spectroscopic examination, contains no unknown elements.

Many comets return periodically, and several of those mentioned in history have been identified as the comets that still return. They move in elliptical paths, many have been "captured" by Jupiter, and their path does not extend far

beyond his orbit. Others describe parabolas or hyperbolas, and these never revisit the solar system.

Meteors are popularly known as falling stars. They are actually minute particles of matter that blaze up and are consumed in their passage through the atmosphere of the earth. At certain periods of the earth's course it enters a region of space containing a large number of these meteors, and then there is an exceptional display of shooting stars, which appear to radiate from one point of the sky. Such are the "Leonids," which radiate from the constellation Leo, in the month of November. In certain years they are particularly numerous. Larger meteors occasionally fall to the earth, but these are independent of the showers. These showers appear to be disintegrated material from comets.

THE STARS AND NEBULÆ

The study of the stars and nebulæ is one of extraordinary fascination, and of equally extraordinary complexity. Recent investigation has revealed the fact that astronomers are face to face with hosts of unsolved problems, and many assumptions are breaking down as knowledge grows. On the other hand, much has been permanently added to the stock of ascertained fact. Only enough can be said here to encourage the reader to examine further into this most attractive branch of astronomy.

We speak, and with justification, of the fixed stars; but careful measurement with the most delicate instruments at his command has revealed to the astronomer that, in spite of their apparent fixity, they have, many of them, motions of their own that are to be measured in many miles per second. And certain groups of stars are all moving in the same direction. The Pleiades, for example, have all the same direction of motion. And photography has revealed clearly what the most powerful telescopes only showed in small degree, that the stars of this constellation are "tangled in a silver braid" of nebulous haze. This shows that in some way they have all had a common origin.

Moreover, it has been found that of the stars whose motion can be measured, and whose motion was assumed to be quite haphazard, a great many belong to two quite distinct groups which are drifting in two directions. Why this should be we are as yet in ignorance. Our own sun is of course a star, and has a motion supposed to be in the direction of Lyra. The stars in that part of the sky are apparently moving farther apart, while those in the opposite quarter of the sky are apparently coming closer together. But the question of the sun's motion is not growing any simpler with later discoveries.

When you are in a train the near objects seem to whiz past, more distant objects appear to move at a more leisurely pace. In the same way the nearer you are to a moving object the more quickly it passes your position. The same reasoning has been applied to the stars. The more quickly moving ones are probably the nearer. On this assumption there are comparatively few stars near us; for the "proper motions," as they are called, of the stars are in most cases too small to be detected at all. Still fewer are near enough to have their distance measured by their parallax. This method depends on observing the position of a star at different times of the year. The earth in March is nearly four hundred million miles away from its position in September. Yet the distances of the stars are so great that only the very nearest stars appear to be different in position at these two times. Light, travelling through space at the rate of over 186,000 miles per second, and taking a little more than eight minutes to reach the earth from the sun, takes three and three-quarter years to reach us from the nearest fixed star. In most cases the time is to be reckoned in hundreds of years. The more one thinks of it, the more one is struck with the almost appalling isolation of each star from its neighbour.

But stars do not only move past us, or we past them; they have also a movement away from us, or towards us. Of this motion the world was in entire ignorance—however probable it might be — till the discovery of the spectroscope. Then, as has already been explained, the shifting of the lines of the spectrum to one side or the other gave a means of measuring the rate of motion to or from us. Wherever this shift is found the rate can be calculated, whatever the distance of the star.

Double Stars.—One remarkable discovery was made in this way. In the case of certain stars, to all appearance single stars, the lines of the spectrum at one time appear double, then they coalesce, then they become double again. This means that these stars are really double stars, revolving round each other, so that at one time one of them is receding and the other advancing; at another time neither is receding or advancing, but moving across the line of sight; then again the first is advancing and the second receding. The rate at which they revolve round each other varies enormously.

Still more, the lines of the spectrum are often seen, not to double, but to shift, first to one side of the normal position and then to the other. This is explained by the fact that the star is really a double, but one member of the pair is dark. The number of these is very great, and is always being added to. At least one star out of every four or so has been shown to be a spectroscopic double; it looks as if this were the normal state of affairs in the universe. No explanation whatever has yet been found to

account for the fact that one member of the pair should be enormously hot, while the other, perhaps as large, should already have cooled sufficiently to be dark.

Many stars are variable in their brightness. In this case it has been shown that a number of the variables are double stars, a bright one and a dark companion, and whenever the dark star comes between us and the bright one there is a loss in light-giving power. In other cases, the variation in brightness is quite irregular, and no cause has been discovered to explain it.

Colours of the Stars.—Every observer must have noticed that the stars differ from each other, not only in brightness, but also in colour. Some are bluish-white, a second class are yellowish, a third class red or orange, and a fourth faint and deep red in colour. These are the four principal types, and starting from these as a basis a more intricate classification has been made.

Type I is exemplified by the Pleiades and Sirius; Type II by the sun; and Type III by Antares. Type IV are too faint to be commonly known.

Spectrum analysis has shown that these are in descending order of hotness, and therefore probably of age. In the case of the sun the light from the glowing photosphere passes through a cooler layer consisting of the vapour of hydrogen and many metals. This cooler layer gives the dark lines of the spectrum. In Type I stars, the absorption is largely due to helium or hydrogen; there is not yet a cooling layer of the metals generally. In Type III stars the spectrum shows flutings that have recently been found to be due to a compound of titanium. They are of a lower temperature than the sun, for the temperature of the sun is too high to permit of such a compound being formed. Type IV stars are at a lower temperature still, as is shown by the flutings due to carbon compounds.

Nebulæ.—The nebulæ have already been mentioned. For long it was uncertain whether the hazy light shown by these might not be simply the light due to clusters of stars too far off to be resolved into individual units. The question was solved when, in 1864, Huggins examined one of the nebulæ, in Draco, with the spectroscope. The spectrum, unlike that of the stars, consisted of a single bright green line. Therefore the nebula consisted of a gas in its uncompressed state, and no amount of extra telescopic power could ever have resolved it into a cluster of stars. Other gaseous spectra of nebulæ also contain this bright green line—called the Chief Nebular Line—though some of these show also the spectra of other gases, such as hydrogen and helium. The green line is due to an element as yet undetected in the elements of earth, and has been called Nebulium.

But Huggins also discovered that all nebulæ are not of this type—indeed these green nebulæ, often called "planetary nebulæ," are in a distinct minority. Others are "white nebulæ," and give a continuous spectrum. These cán be counted by thousands. The extraordinary fact about these is that most, if not all of them, are spiral in shape, the spiral having two arms with knots of nebulous material at intervals along the arms. These are to be found in all stages of development, and the suggestion has been made, and meets with a great deal of support, that in these we can see the beginnings and the continuation of an evolution destined to end in the establishment of a system similar to our solar system. Our own system is therefore a spiral nebula carried a stage farther than those we see. But the hypothesis is an hypothesis merely. Too little is known as yet about the spiral nebulæ to allow of dogmatism, and the vastly large scale of these nebulæ is in itself a difficulty.

Everyone is familiar with the Galaxy or Milky Way. Apparently the Universe extends farther in that direction than in other directions. In the Milky Way are enormous numbers of very faint stars, and also a great amount of nebulosity. The stars, of whatever magnitude, increase in number as the Milky Way is approached, and nearly all the gaseous nebulæ are congregated along it. But it is a striking circumstance that the spiral nebulæ seem to avoid the Galaxy altogether. Surely here is cause for profound speculation as to the structure of the Universe. So far, astronomers are at a stand. The mystery is still unsolved, and with this subject of meditation we leave the student.

COURSE OF READING

Of popular books on Astronomy the name is legion. Only a few can be mentioned here. *Star-Land*, by Sir Robert Ball, is a very interesting book, primarily meant for young people, but containing a great deal that will instruct those of more mature years. Young's *General Astronomy* and Moulton's *Introduction to Astronomy* are full and readable. In the People's Books *The Science of the Stars*, by Maunder, and *Practical Astronomy*, by Macpherson, approach the subject from different standpoints, and each in its own way gives great help to the student. In the same series *Sir W. Huggins and Spectroscopic Astronomy* is a fascinating account of an important branch of the subject, by Maunder. The account of *Astronomy*, by A. R. Hinks, is also of great value. Any of these books will give a fuller bibliography.

Philips' *Planisphere*, as has already been mentioned, is of great use in studying the constellations. Peck's *Constellations and How to Find Them* is valuable for beginners. The

New Star Atlas, by Proctor, ought also to be mentioned.

Everyone who intends to study the stars ought to have a copy of the current year's *Whitaker's Almanack*, which gives good monthly notes as well as a general dissertation. *The Nautical Almanack* is more advanced. For some work a celestial globe is essential. Most of the daily papers give a monthly account of various astronomical features of interest. Finally, in order to keep abreast of a subject in which fresh discoveries are constantly being made, one of the astronomical journals should be read. Of these mention may be made of the *Journal of the British Astronomical Association* and the *Astrophysical Journal*.

George S. Dickson, M.A., B.Sc.

METEOROLOGY

Introduction.—It must be confessed that Weather Science, or Meteorology, as it is called, is still in its infancy. Of course, no science whatever has yet had its final volume written. Many a time, as the worker in a particular branch of science seems to be at last reaching the limit of human knowledge, new methods of attack, or fresh discoveries, open up wide and hitherto undreamed-of vistas. As an example of this, Astronomy, one of the oldest of the sciences, may be cited. But, though observation of the weather must date at least as far back into the mists of the past as observation of the stars, yet even the first volume of this science is not yet completed, or is no more than completed.

For science deals with a body of accurate and organised fact; and a great many of the facts of the weather have not yet been ascertained at all. Systematic observation over wide areas only began a little more than fifty years ago. Already a great deal has been done; some of the tangled web has been unravelled, some principles have been established; but much remains to do.

It is impossible to hasten the process. Laboratory experiment, which so often is able to imitate the methods of nature and thus reveal her secrets, is practically impossible here. Yet time will tell. Already, thanks to the diligence and skill of investigators, some old theories have gone by the board, and some new theories, rather disquieting to the conservative mind, are taking shape. But all authorities have to admit that many weather phenomena, if not most, still await their explanation. "We cannot tell" has still to be answered to many inquiries.

Knowledge, however, is growing. One eminent worker in this field cannot publish a certain book, eagerly awaited byother students of meteorology, because research continues to reveal another and yet another factor that must somehow be taken into consideration. This short account, therefore, can only give the student a brief summary of the present state of knowledge, that he may be able to grasp the significance of the results of further investigation.

General Principles.—A good deal of the work of the meteorologist has a bearing on the work of the geographer. Wind systems, their causes, their relation to climatic zones, their effect on the earth as the abode of man, are intimately connected with geography. Therefore much that geography touches on is omitted here, and for an account of such matters as trade winds, equatorial rain-belt, prevailing westerlies, and the like, the student is referred to the article on geography. Here, certain statements have to be made from the meteorological standpoint.

(1) *Atmospheric movement* is primarily due to solar radiation. About half of the radiant energy of the sun is absorbed in passing through our atmosphere, the rest reaches the surface of the earth unchanged. By far the greatest part of the energy reaching the surface is converted into heat, and this heat is passed on by conduction to the lower strata of the air.

Now when air is heated it expands, and when it expands it becomes lighter, bulk for bulk. And if air at any particular place becomes lighter than other air in the neighbourhood, that other colder and heavier air flows in underneath it and causes it to ascend. A common way of putting this statement is to say that the lighter air rises, and the heavier air flows in to take its place. This is a case of putting the cart before the horse. It is a relic of the old figment that Nature abhors a vacuum. The air is forced up, just as a cork at the bottom of a pail of water is forced up. If there were nothing but cork, or if there were nothing but light air, there would be no tendency to rise.

The fact that the sun heats different parts of the globe unequally may here be taken for granted. We all know that the equatorial regions get more heat than we do; and we ourselves get more heat in summer than in winter. Then land heats up more quickly than water, and cools down more quickly; and certain kinds of soil heat more easily than others. The differential heating of the atmosphere is therefore accepted without further question.

But it is obvious that if the air is heated unequally there must be movement from places where the air is heavier to places where it is lighter; or, to put it otherwise, wind blows from places of high pressure to places of low pressure. This establishes the first important fact.

(2) *Aqueous Vapour in the Air.*—Next comes the fact that air is able to hold water, in the form of aqueous vapour. The warmer the air is the more aqueous vapour it is able to hold. When air contains as much water as it can hold it is said to be saturated. With the least

further cooling it would have to reject some of the water—that is, the water would cease to continue in the form of vapour. It may be deposited as dew, or may remain suspended in the air in the form of mist. Going to extremes, rain or snow may fall.

If saturated air is allowed to warm up still further, and not allowed to absorb any more moisture, it becomes unsaturated, and could be cooled back to its old temperature without any moisture being set free. When the air is above the point of saturation it is said to be dry, even although there is water in it; because it has no tendency to part with what is there already, but rather to take in more. The higher it is above the saturation point the greater will be the tendency for it to take in more water wherever it gets the chance.

It may be mentioned that when water passes from the state of vapour to the state of liquid, heat is liberated; and conversely, when water is evaporating, heat is taken up, or cold is produced. The explanation of this belongs to the domain of physics. Probably most are familiar with the cold produced by the rapid evaporation of a drop of ether placed on the hand, and with the fact that water can be frozen by the evaporation of ether. Although water evaporates less rapidly than ether, the kind of effect is the same.

Now, it is important for the meteorologist to know how near, or how far from, saturation air is. This may be found out by cooling down the air until the dew-point is reached. This is a tedious process, and as a rule it is found by using a "wet and dry bulb thermometer." This consists of two thermometers side by side. The bulb of one of these is covered with muslin that is kept constantly wet. The more unsaturated the air is the more quickly will the water be evaporated from the muslin. But as has been said, the evaporation causes cold, and the more quickly the process is going on the lower will the reading of the wet bulb thermometer be. Thus the difference between the readings of the two thermometers is an indication of the "dryness" of the air. Tables have been constructed to show from the difference in the readings the amount of water vapour present in the atmosphere.

(3) *Warm and Cold Winds.*—Air may grow warmer by blowing to warmer parts of the earth's surface, as is the case with the trade winds blowing towards the equatorial region. As it warms up it is able to hold more moisture, and therefore these winds are drying winds. On the other hand, winds blowing towards the poles are growing colder, and more likely to be rain-bearing. This is the case with the westerlies that blow over our country.

(4) *Expansion and Compression of Air.*—But one great factor is the expansion and compression of the air. Everyone who has blown up a bicycle tyre knows how hot the pump gets, the heat being solely due to the compression. You may work a pump unattached to the tyre for as long as you please without any rise in temperature. In the same way expansion causes cold. Therefore if air is compressed it becomes "dry"; if it expands, it may soon fall below the saturation point.

What, then, can cause air to expand? It may be stated in a sentence. Ascending currents of air expand, descending currents contract. This is quite what is to be expected. If a pile of "family balances" were stacked one on the top of another, the topmost dial would register no weight at all, and the registered weight would increase as you go downwards. Similarly, there is no weight pressing on the air in the upper regions of the atmosphere, whereas the bottom layers of the air have to support all the weight of the superincumbent air, and this weight compresses it closely together, just as the spring of the balance is compressed.

When air rises, it escapes part of this pressure, and is free to expand. And when it expands it cools. And when it cools it is able to hold less moisture, and rain falls. Contrariwise, descending air is becoming subjected to greater pressure; as it becomes compressed it becomes warmer, and able to hold more moisture. Further discussion of this will be more appropriate later.

We are now ready to proceed to the kind of work that may be done locally.

LOCAL METEOROLOGY

We are naturally most interested in the weather of our own district. The man in the street gets up in the morning hoping it will be a good day, but there, as a rule, his investigations end. It is somewhat different with the man in the fields, to whom the weather is a much more important factor. Lack of rain, or excess of it, may mean to him a year's work lost. Frost may come too soon, or hold off too long. Lambs may die of cold, grain may not ripen, pasture may be burnt up; in hosts of ways the weather is to him a matter of supreme interest. Therefore it is that many an old shepherd or farmer becomes weather-wise, and can interpret the signs of change in a way that puzzles the townsman.

But his interest, too, is limited. Of the causes of change he neither knows nor cares much, and if he is transplanted to unfamiliar surroundings his skill is of little avail. The student must not rest content with this kind of knowledge. He may easily be outshone in weather prediction by many a local wiseacre, but this need not deter him from scientific inquiry.

One of the troubles that meet the student at the outset is that a long period of observations

is requisite before any trustworthy data can be secured. But, on the other hand, there is the great compensation of knowing that in this science, more perhaps than in any other, first-hand observations contribute largely to the stock of data without which no science of meteorology could exist at all.

Now what are the observations spoken of, and what instruments are required for making them? How much can the student do with a very limited stock of apparatus?

(1) Prevailing Winds.—He can begin by discovering the prevailing winds of his district, and the kind of weather to be expected with each wind. This means keeping a record for as long a period as possible His record will be of use, not only to himself, but to others. On a sheet of paper let him make a set of columns as follows:

Date.	Direction of Wind.	Strength of Wind.	Kind of Weather.

The nearest weather-vane will give the direction of the wind; the strength of the wind is generally expressed as a figure, 0 is taken to represent a calm, and 12 a hurricane. This is the scale known as Beaufort's Scale, from the name of the admiral who first recommended this and other symbols for representing the weather.

This scale has been worked out in great detail, that the figures of different observers may be standardised as far as possible. Otherwise a beginner might easily feel lost in his attempts at estimation.

When smoke rises vertically the number 0 is used; when it begins to drift, the number 1 is used. The whole scale is here given in an abridged form:—

Beaufort Scale.

0	Vertical smoke.
1	Smoke drifts.
2	Vane moves; leaves rustle.
3	Small twigs in motion; light flag extended.
4	Small branches move; dust and loose paper blow about.
5	Small trees sway.
6	Whistling in telegraph wires; umbrellas used with difficulty.
7	Whole trees in motion; inconvenience felt when walking against wind.
8	Breaks twigs off trees.
9	Chimney-pots and slates removed.
10	Trees uprooted; considerable structural damage.
11	Widespread damage; very rare inland.
12	Hurricane.

Since the wind blows, not steadily, but in gusts, it is difficult to give the velocity of the wind in miles per hour to correspond to these divisions. Indeed it is not attempted; they are classified in groups, with a maximum and minimum velocity to correspond. The first half of the scale may roughly be said to include winds up to 30 miles per hour; anything over 75 miles an hour is a hurricane.

In observatories *anemometers* are used to measure the velocity of the wind, or its pressure.

The column in the student's table showing kind of weather needs little explanation. In this column will be recorded whether the day is warm or cold, wet or dry, whether hail has fallen, or snow, whether there is fog or mist, clouds or blue sky, and the like.

At the end of a month the results may be summarised. A wind star may be drawn, which will show at a glance the direction of the winds for the month. The number of wet and dry days may be tabulated. The diagrams show the sort of thing that can be done (Fig. 1).

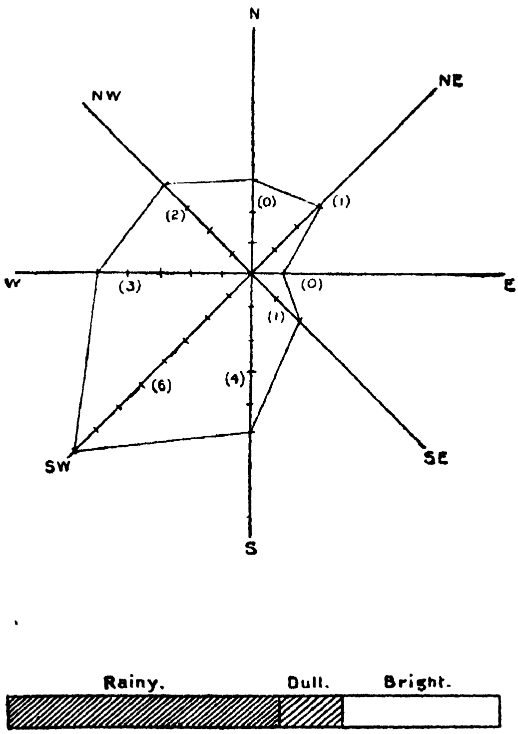


Fig. 1.

They explain themselves. Note that in the wind star there are certain numbers in brackets. For instance, along the west wind line is the number (3). As can be seen there are actually five days of west wind; the (3) shows that three of these were rainy days. This correlation of wind and rain is of great importance.

The student will note that the wind star shows at a glance the direction of the prevailing winds for the month. He will also realise at once that such a star for a single month is of little value in itself. This particular instance shows that more than half of the winds of the month were S., S.W., or W. But a long series of observations would be necessary before the observer could say that the prevailing winds were always from these directions.

(2) **Use of the Barometer.**—The above set of observations, it will be seen, requires no instruments at all. When the question of instruments comes in, there is no doubt which is the most important of all for the meteorologist. It is the Barometer. One may say that it was the discovery of the barometer by Torricelli in 1643 that made meteorology possible. Nowadays we all know that air has weight, that it exerts pressure, but this was not always understood. Torricelli took a glass tube, about three feet long, and closed at one end. This tube was filled with mercury and inverted over a dish also full of mercury (Fig. 2). The mercury in the tube at once fell until it stood at a height of about 30 inches above the mercury in the dish, leaving a vacuum at the top of the tube. Thus was exploded an old belief. As Carlyle says, "*Nature abhors a vacuum!* how exceedingly false and calumnious." This column of mercury, somewhere about 30 inches high, is supported by the pressure of the air on the mercury in the dish, and is a measure of the weight of the air. At sea-level, the weight of the air is about 15½ lbs. per square inch.

FIG. 2.

This is not the place for going into details of the theory or working of the barometer; but it may be noted that the kind of barometer often seen in the halls of houses, with a dial and revolving pointer, is of little value for scientific purposes.

The important thing for us is that the barometer shows that the weight of the air is not a constant quantity. It is constantly fluctuating, and as it fluctuates the mercury in the barometer rises and falls. The observation of the barometer is one of the most fundamental acts of the meteorologist. In all cases the barometer ought to be observed twice a day, the customary times being 9 A.M. and 9 P.M. Sometimes a barograph is used, which records the variation of the barometer from moment to moment.

The student ought to observe for himself the kind of weather that accompanies a high or a low barometer, a rising or a falling barometer. Probably all this is absolutely familiar to everyone, but everyone does not keep a record of daily readings. It only means the addition of another column to the table already described.

A barometer chart for the month ought also to be made on squared paper.

One other observation has to be made with the barometer, that is, how the weight of the air varies with the height. The higher one goes, the less is the quantity of air weighing down on one, and therefore the lower will the barometer stand. Experiment shows that this is the case. It can be shown quite easily with a pocket aneroid barometer. These are often sensitive enough to show the difference in the weight of the air at the top and bottom of the stairs in a house.

It is generally accepted that the barometer falls about 1 inch per 1000 feet rise for low altitudes, but the rate of fall slows up as one ascends.

(3) *The Thermometer.*—Next in importance to the barometer comes the thermometer. And for our purpose thermometers showing maximum and minimum temperatures are essential. Sometimes a single thermometer showing both maximum and minimum temperatures is used. To the table as already constructed columns should be added to show the daily maximum and minimum temperature.

Temperature, like air pressure, diminishes with height—a rise of 300 feet giving a fall of 1° F. This fall continues until a height of about six miles is reached. One of the most unexpected discoveries made by recent investigation is that after this height is reached the temperature remains unaltered whatever greater height is attained. There may be alteration from day to day, and from place to place; it may be 60° below freezing-point on one day, and 70° the next; it may be 60° below freezing-point at one place, and 70° at another; the essential thing is that whatever it may be at one place on a certain day, at that point the temperature remains, at whatever height—seven miles, eight miles, nine miles—the thermometer reading is taken.

(4) *The Rain-gauge.*—The next important instrument is a rain-gauge. The rain falls into a receiver, of known area at its mouth, and from the receiver it is poured into a measuring glass, which is graduated to read the rainfall in inches and fractions thereof. This means still another column to be added to the table recording the weather.

There are numerous other instruments that might be mentioned, such as the sunshine-recorder, the wet and dry bulb thermometer, &c., but those mentioned above are the most important.

The rain-gauge must be placed in a very open position. It must not be near a building that might shelter it from wind and rain, nor must it be in a place where there are eddies in the wind.

The thermometer must be freely exposed to the outside atmosphere, at a height of four feet from the ground, but must not get the direct rays of

the sun. Thermometers are also used to give the temperature on the level of the ground, and to give the temperature in the sunlight.

In reading the barometer the important thing is to know what it would read if the place of observation were at sea-level. For rough purposes it is sufficient to add one-tenth of an inch to the barometer reading for every hundred feet above sea-level. For accurate work it has to be corrected not only for height, but also for temperature. Since mercury expands when heated, the same weight of air on a warm day will give a longer column than on a cold day.

For many purposes the thermometer reading, too, is reduced to sea-level.

The above account gives with sufficient fullness the amount of work that can be done by a student in observing the local weather. No one can complain that any of it is hard; the real trouble is that it is apt to be tedious, and may easily become slipshod and inaccurate. There is room for a great many more workers who will undertake just the kind of work described, and either take the daily readings themselves or leave it to a competent substitute when they are unable to discharge the duties.

As an example of this, reference may be made to the phenomenal rainfall of August 25 and 26, 1912, in East Anglia, when over seven inches of rain fell in one day at certain places. In an account of this, which appeared in the *Quarterly Journal of the Royal Meteorological Society*, great regret was expressed at the lack of rain-gauges in the district—a lack which considerably hampered the investigation of the occurrence. It was also evident from the account that in one or two cases the observers had allowed their work to be carried out with insufficient care.

SYNOPTIC METEOROLOGY

We must now enlarge our horizon. This is done by combining the observations made by as many sets of observers as possible. The results of one observer, taken by themselves, could never take us very far. But when a synthesis is made of the results of many observers, there is revealed what practically amounts to a new class of facts. To use a crude comparison, many features have to be studied in order to comprehend a human face. Prolonged contemplation of a nose by itself gives little knowledge of the general appearance. Now, when the observations of a large number of students are united into one whole, it is found that they fall into place and form a definite system, which the most brilliant single observer might remain in ignorance of for ever. It would be more correct to say that they form, at any one time, one of a very few clearly distinguishable systems.

To become more definite, let us take a very common condition in the British Isles. Your own reading of the barometer, let us say, shows that the air-pressure is 29·2 inches. This information is forwarded to headquarters, where it is set down on a map, along with the observations sent from other stations. For clearness we shall keep the number small. The result at first sight isn't encouraging—a mere confused gathering of dots (Fig 3).

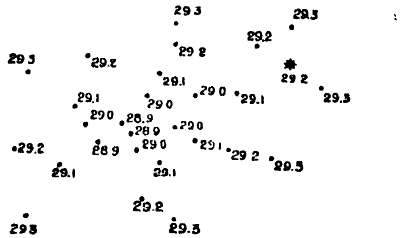


FIG. 3.

But when lines are drawn joining all the points of equal barometric pressure, the following rather remarkable diagram is the result (Fig. 4).

Suppose your own station is the one to the right of the figure marked *. Then as you continue to observe the barometer you will find that it falls steadily to 28·9 inches, and then begins to rise. Your own and the other observations show that the condition indicated by the diagram is moving away to the right, in the direction indicated by the arrow. (The student will find it useful, when he is studying weather

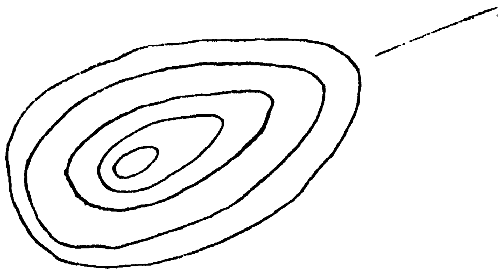


FIG. 4.

diagrams of this sort, to draw them on transparent paper, and then, by moving them over a map in the appropriate direction, he can easily follow the sequence of winds, rain, and weather generally, at any particular spot. This is sometimes a more misleading thing than one would imagine.)

The lines joining the points of equal pressure are called *isobars*. The whole system is called a *cyclone*.

Distribution of pressure, cyclonic or otherwise, is not always so definite as this, but cyclones are so common in Britain that we shall proceed at once to discuss this type in greater detail.

The word cyclone is apt to call up in some minds the idea of a terrific storm, but this need

not be the case. It is used by meteorologists to indicate a condition of the air, as in diagram, in which the barometric pressure is least at the centre and greatest at the circumference. Most storms are cyclonic, but it cannot be said conversely that most cyclones are storms.

Cyclones.—The first point to settle with regard to a cyclone is the direction of the wind. This is a mere matter of observation. And the result of observation gives the following general principle. The winds in a cyclone blow inwards towards the centre in a spiral. In the northern hemisphere the rotation is in a direction opposite the direction in which the hands of a watch move, it is "counter-clock"; in the southern hemisphere the direction is "cum-clock." If you stand with your back to the wind in this hemisphere, the low pressure is to your left hand; in the southern hemisphere it is to the right hand. This is known as "Buys Ballot's Law."

Taking the outermost of the isobars in the last diagram, the winds blow as shown (Fig. 5).

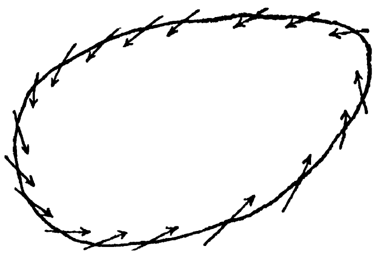


FIG. 5.

With the other isobars the general direction of the winds is the same.

It has recently been shown that in the upper air the winds blow much more nearly straight along the isobars.

Notice that if you select a suitable place in the cyclone, you can have the wind blowing from any point of the compass you please. Although this is so, it must not be forgotten that the whole system is moving eastward, in the direction indicated by the arrow, at a velocity varying with the individual cyclone. Occasionally a cyclone will be found moving westward, but this is rather a rare occurrence.

Why does the wind blow spirally towards the centre? If wind blows towards regions of low pressure, why does it not blow straight there? The answer is that the spiral motion is due to the rotation of the earth. Let us try to illustrate and explain this as clearly and as simply as possible.

You have all seen water running out of a bath. To begin with, the water goes straight to the outlet. But if with your hand you make the water go, not directly to the outlet, but to the side of it, what is the result? The water, if we may put it that way, wishes to go directly out, but it has got a sideways movement, due to your action, and misses the exit. Still trying to escape, it now turns towards the outlet, and by keeping turning a whirlpool is set up. As you know, once this is started, it tends to persist without any aid from you.

Take the case of a cyclone. The whole earth is rotating, but obviously the movement is greater near the equator than farther north. Suppose we consider a quantity of air near the equator, and a centre of low pressure directly north of it. Both of these are rotating eastward with the motion of the earth, but the point farther south has the greater rate of motion. This assumed quantity of air starts to move directly to the low pressure centre, but thanks to its greater motion eastwards it really has a sideways motion, and therefore misses the point it aimed at, passing to the east of it. It now tries to rectify its mistake, and turns towards the centre. Thus the cyclonic movement is set up.

In the case of a quantity of air to the north of the low pressure, the same reasoning shows that it also misses the centre, but in this case it is too slow, and passes the centre a little to the west, thus strengthening the spiral movement.

The fact that the whole system is moving to the east does not invalidate the argument at all.

The water in the bath escapes downwards, but the air in a cyclone escapes upwards, and at the centre there is a steadily ascending current of air. This means, as has already been shown, that rain will fall.

Centre of the Cyclone.—But in many especially in the tropics, but even in this country, there is a clear space in the very centre of the cyclone, commonly called the "eye of the storm." Without going into this elaborately, it may be said that the reason of this is as follows. Near the centre the whirling motion of the winds is so great that they cannot reach the centre at all, and begin to ascend without coming any nearer. But in the centre there is low pressure that demands to be filled up, and is filled up, not by the winds, but by air drawn down from higher up. There is therefore at the very centre a region of descending air, and therefore a region of air that is warming as it descends, and therefore a region where no rain falls.

Rain does not only fall near the centre of the cyclone. There is so much air at the outside of the cyclone trying to reach the centre that there is no room for it all there, and a great deal of it must ascend, and the usual consequence of ascension follows.

Sometimes the wind blowing spirally from the south-west comes across a wind blowing in from the north-east. The former is generally the warmer and lighter, and simply blows

over the top of the colder and heavier north-east wind. As soon as it ascends heavy rain falls.

This phenomenon of a colder current forcing a warmer one to rise, and thus producing rain, is not confined to cyclones. It gives rise to what is generally called a "line squall," a term that one frequently meets with in the daily weather reports of the newspapers.

Sequence of Weather in Cyclones.—The next thing to do is to trace the sequence of the wind and weather as the cyclone passes over a certain spot. There are obviously three cases to be considered: when the centre passes right over the spot, when it passes to the south of the spot and when it passes to the north (Fig. 6).

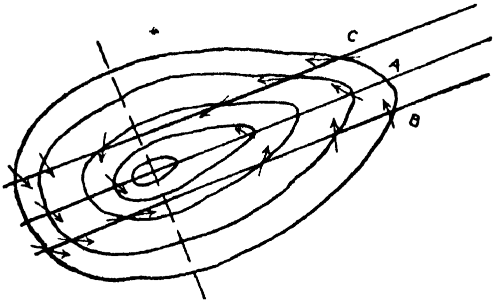


FIG. 6.

Taking the same diagram as before, consider what happens at each of three stations, A, B, and C, as the cyclone passes.

At A the wind begins by being south-east. Now A remains stationary, and the cyclone passes over it. Soon the next isobar will have reached A; but the wind is still south-east. And south-east it remains till the centre passes over A. This is often shown by a clear spot in the sky; and a calm takes the place of the wind. When the centre has passed over the wind begins again, this time, however, from exactly the opposite direction.

Next examine B. The wind of the cyclone begins by being about south-east. As the cyclone passes, the wind is in turn S., S.W., W., and N.W. That is, the wind has gone round in the same direction as is taken by the sun, which rises in the east, and works its way round *via* south to the west. Wind which follows this direction is said to "veer."

Lastly comes C. In this case the wind, almost east at first, works its way round to north-east, north, and so on to north-west. It has thus gone in the direction opposite that taken by the sun. Wind which alters in this direction is said to "back."

In the case of B, if the wind is west before the cyclone comes on, it will back to begin with, and then begin to veer. In the case of C, the wind backs continuously.

As the cyclone comes on, the barometer begins to fall, the air grows damp and muggy, the wind increases, and soon rain falls. This continues till the "trough" of the cyclone, shown by the dotted line, is passed; then the barometer begins to rise, the air becomes exhilarating in place of being oppressive, passing showers take place, and the cyclone is over.

There is some little difference in the behaviour of the weather to the north and to the south of the central line; but for the explanation of this, and of the passing showers in the rear of the cyclone, the student must refer to the books for further study mentioned at the end of the article.

Strength of Wind in Cyclones.—It will be obvious to everybody that the greater the difference in pressure between the outside and the inside of the cyclone, the stronger will be the wind, if we assume, that is, that we are dealing with cyclones covering the same area. The universally adopted simile is that of the gradient of a road or railway. To know whether wind will be strong or not, the "barometric gradient" must be known. Taking still the same diagram, the barometric heights along the line beginning at A can be represented on a chart thus (Fig. 7):

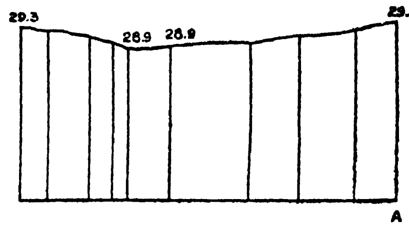


FIG. 7.

For another cyclone, the slope might easily be steeper, or more gentle. The steeper the slope the greater the force of the wind. Also, the steeper the slope the greater the number of isobars, if these are drawn, as is customary, at intervals of $\frac{1}{10}$th of an inch. Therefore we may say that the closeness of the isobars is a measure of the force of the wind.

The above diagram also makes clear the meaning of the phrase "a depression is approaching."

In the course of time a cyclone becomes dissipated. But experts in these matters can predict with some approach to accuracy the course that it will take. The position and condition of a cyclone on a certain day enables them to indicate where it will be the next day. Thus arises the science of forecasting the weather.

Anti-cyclones.—Another condition that we frequently experience is the anti-cyclonic. As its name implies, this represents a state of the air in which pressure conditions are exactly the reverse of cyclonic. That is, there is an approximately circular or elliptical area over which the

barometric pressure is highest in the centre and decreases to the circumference.

This, of course, involves essentially different weather conditions. Air gradually passes from the centre outwards. Under the influence of the earth's rotation the movement of the air is a spiral, but in this case the movement is *cum-clock*. Imagine a mass of air at the centre. This mass is moving due south to a region of lower pressure. But, being farther away from the equator than the point it is making for, it finds on reaching the circumference of the anti-cyclone that the earth there has slipped some distance round. It therefore strikes the circumference at a point to the west of the south point it was aiming at. Therefore it reaches that part of the earth as a north-east wind. Notice that although our hypothetical air mass has not reached its original objective it has reached a point equally satisfactory, for there is low pressure all along the circumference. Notice, too, that there is nothing to cause any violent swirl such as characterises many cyclones, and therefore there is no fierce rush of air similar to what is often found under cyclonic conditions. The airs of an anti-cyclone are typically gentle.

As the air moves out from the centre, more air descends from above. There is compression of the air as it descends, and accordingly, instead of parting with moisture, it is able to absorb more. Therefore the existence of an anti-cyclone means dry weather.

Anti-cyclonic Weather Conditions.—As a general rule, we may say that during an anti-cyclone there is a cloudless sky and little wind. During the day there is strong sun, and much moisture is absorbed by the atmosphere. The surface of the land gets heated up strongly.

But when night comes, the absence of cloud allows the heat of the earth to be radiated freely into space, and the ground speedily becomes cold. It may become cold enough to cool the adjacent layers of air below the dew point, and fog or mist is the result. In summer the next day's sun is soon able to dispel the mists, and another day of bright sunshine succeeds.

In winter, the state of affairs may be different. The long night means more mist, and the feeble sun of the short winter day may not be sufficient to clear it away. Particularly is this the case in cities, where the particles of smoke facilitate the condensation of the aqueous vapour in the air. It has often been remarked that when city fogs are at their worst, and artificial lighting goes on all day, within a few miles there may be keen air and bright sunshine.

When once an anti-cyclone is fully established, it tends to be a very stable condition of the atmosphere. There is in general a movement eastward of the anti-cyclone as a whole, but it is a slow process; sometimes the condition remains practically stationary for many days on end. These are the circumstances favouring drought in summer, and severe frost in winter.

Occasionally the anti-cyclone is of a different type so far as weather is concerned. Then the sky is leaden, the sun hardly appears, the temperature is not high during the day, but on the other hand the covering of cloud prevents radiation at night, and the temperature does not fall much.

Once those two types of atmospheric distribution are known, it is possible to go on to other ways in which the pressure may be arranged. Some of these will now be mentioned.

(1) **Secondary Depression.**—Alongside a cyclone the isobars may be found to have distributed themselves as if in an attempt to form a new cyclone. The stages of success they reach are various; they may be so well developed that the name scondary becomes a misnomer. The diagram shows a secondary in a fairly advanced stage (Fig. 8).

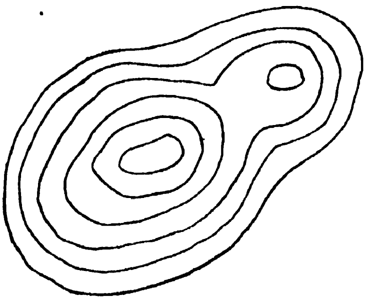


FIG. 8.

The weather in this case is of the cyclonic type; but between the primary and the secondary the conflicting interests of the two centres produces a state of calm. Thunderstorms are a frequent accompaniment of secondaries.

(2) **Wedge.**—It often happens that in this country there is a succession of cyclones. It has been said by observers that when the centre of a cyclone passes to the south of these islands, there is a less tendency for another to succeed it. This path is shown by the wind "backing" as the cyclone passes.

But if two follow each other, what is the condition between them? The result is a

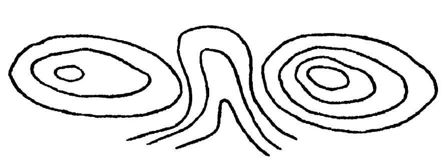


FIG. 9.

"wedge," as in figure. For simplicity the number of isobars is kept small (Fig. 9).

There are two centres of low pressure here. From each the pressure increases outwards;

therefore the maximum pressure will lie on the axis of the wedge. This gives a condition comparable to the anti-cyclonic; and, generally speaking, anti-cyclonic weather prevails.

(3) **V-shaped Depression.**—This is the reverse of a wedge. It generally points southward. As its name implies, it comes between two areas of high pressure, and the axis of the system is a region of low pressure. It therefore corresponds to some extent to the cyclonic type.

Some Meteorological Phenomena—*Rain and Clouds.*—When air is cooled below the dew-point, the aqueous vapour ceases to be vapour and condenses as minute particles of water. This condensation is aided by the presence of dust or other solid material, which acts as a nucleus on which the moisture is deposited. These tiny particles would take a long time to fall to the ground even in undisturbed air, but with air in motion, especially the upward motion to which condensation is so often due, they tend to remain suspended for an indefinite time. They themselves now form the nucleus for the condensation of the vapour still uncondensed, and thus grow bigger. They may also coalesce with each other. In this way they become so large that the force of gravity more than balances the upward movement, and rain falls. In clouds the two forces may just balance each other; or drops large enough to begin to fall may form, only to evaporate in the unsaturated air below. Often on the lee side of a high mountain a banner of cloud may form. Although this seems a permanent structure, the particles composing it are by no means stationary. The air is driving against the side of the mountain, is cooled there, mist is formed, and then it passes beyond the sphere of influence of the cold mountain, and the mist is re-evaporated. But meantime more air has come up, and more mist is formed.

Snow.—When the temperature of the air falls below freezing-point, the water not only condenses, but freezes. It freezes in the crystalline shape characteristic of water. The little six-sided or six-rayed crystals, interlocking, form snowflakes. Sometimes the crystals form little soft balls. This is the soft hail of winter. When snow falls into warmer air, it gives sleet.

Hail.—This is a summer phenomenon, taking place during thunderstorms, or at least during the weather conditions of thunderstorms. It is formed when air is ascending, as it does in the centre of a cyclone. The moisture is first condensed into drops. These are then carried so high that each drop is frozen. It then becomes covered with a coating of snow. As the air ascends it begins to spread out from the centre, the drop gets out of reach of the whirling mass of ascending air, and falls. But as it falls it is drawn once more into the vortex, and once more ascends. Meantime, it has been covered with moisture while it has been so far down as to be below freezing-point. This moisture freezes in its turn and becomes covered with snow. Thus the drop consists of alternate layers of clear ice and soft snow. If the air motion is very violent, this process may go on till the hailstones attain considerable size. At last they must fall, and often the rattling noise made by the collision of the hailstones in their downward path is quite a noticeable feature. When they strike the ground they often rebound in a lively sort of way, that indicates that they are highly charged with electricity. When they are of large size, the destruction they cause may be enormous.

Thunderstorms.—Most people are aware of the sultry conditions that precede thunder. It is not so generally recognised that this condition is the actual cause of the storm, and the longer it lasts the more severe will be the storm.* The cause of the electrical state of the atmosphere which produces so great results is as yet very obscure. But, as thunderstorms have been watched from their genesis to their conclusion, the visible phenomena are well known, and the inferences to be drawn from them.

The great majority occur on summer afternoons. The heat of the sun has warmed up the surface of the earth, which in turn has warmed up the air next it. There is no breeze to carry away this heated air and mingle it with the colder air. Thus the lower layers of air grow very hot; they expand, and thus become lighter than the air immediately above. This sets up an obviously unstable condition of the atmosphere: it has become top-heavy. It is easy to see that with a globe so little uniform as ours, there will be some place where conditions are at last favourable to the beginning of an up-draught of air calculated to rectify the instability. Once this has begun, the whole atmosphere topples over with a violence to which one might almost compare the toppling over of an iceberg when warm currents have made it top-heavy. All the lower air rushes for this place of escape; it ascends as up a chimney, and spreads out over the upper part of the firmament. Being hot and highly charged with

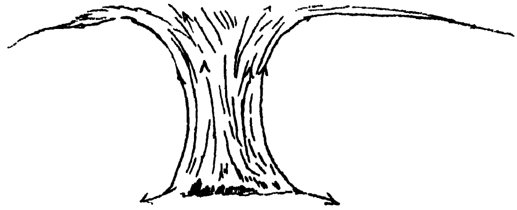


FIG. 10.

vapour, condensation begins very soon in the ascent, and a cloud is formed that has been compared in shape to an anvil, as shown in sketch (Fig. 10).

The idea that thunderstorms travel against the wind is not so ill-founded as several other popular notions. For from the lower edge of the cloud a gust of wind blows outward and downwards. This is explained by the fierce upward rush of the air; and has fittingly been said to resemble the kick or recoil of a gun when fired. Thus when a thunderstorm approaches, the onset is heralded by a blast of wind coming from it.

COURSE OF READING

The student ought first of all to make himself familiar with the general atmospheric circulation of the globe. For this purpose he ought to read carefully the section on this subject in the article on Geography.

When this has been mastered the next point is to know something of the climate of Britain as dealt with by geographers. A good start can be made with this by reading the section on the climate of Britain in the Geography article. It will clear his mind of several preconceived notions, and prepare him for further work.

After this, he may read the general account of weather phenomena contained in some book of physical geography or physiography. One of the best of these is *The Realm of Nature*, by H. R. Mill. It will be found exceedingly interesting reading, although some of it may require close application in order to be understood. The student must therefore be careful that he has grasped the different points and not jumped to some erroneous conclusion.

This book leaves the student with a good many points on which he will desire more detailed information. This is unavoidable in so brief an account. For an account of the different distributions of atmospheric pressure see *Weather*, by Abercromby. This enters into the subject very fully, discussing the weather and all phenomena accompanying cyclones, anti-cyclones, and the rest. If the student can obtain the book, he ought to read at least what is said of cyclones and anti-cyclones, and also see how the author groups the different kinds of atmospheric distribution.

If the student wishes to pursue this aspect of the subject more fully, let him consult *A Popular Treatise on the Winds*, by Ferrel. In spite of its title, it is not a book for the general reader with no previous knowledge of the subject.

Probably the book that gives the best account of Meteorology in its different aspects is *Elementary Meteorology*, by W. M. Davis. It is not elementary in the sense that it is adapted to young children. Of this author's many contributions to the subject mention may be made of a small book, *Whirlwinds, Cyclones, and Tornadoes*, which deals with these matters in a clear and interesting way.

In the latest edition of the *Encyclopædia Britannica* there is an article on "Meteorology." It is very stiff reading, and the student is advised not to read it until he has a good general knowledge of the subject. It is valuable as a contribution to the subject, but is hardly to be followed by a beginner. The article on "Climate" might be consulted, however.

Good use can be made of a meteorological atlas. Most ordinary atlases nowadays include maps dealing with this subject, and these are valuable so far as they go. The *Atlas of Meteorology* (Bartholomew) is the best of its kind, but the student may find difficulty in having access to it.

The student can hardly be expected to buy all the books dealing with this subject. Fortunately, the possessor of *The Realm of Nature*, and *Davis's Elementary Meteorology*, is well provided for all ordinary purposes.

The solitary worker may do a great deal to advance the cause of this science by keeping a record of local weather. Whether he does this or not, he ought to read carefully the instructions as to methods of observation contained in *The Observer's Handbook*, published by the Meteorological Office, or *Hints to Observers*, issued by the Royal Meteorological Society. The Meteorological Office also issues a *Barometer Manual for the Use of Seamen* that is extremely useful for observers. The first of these pamphlets gives information as to what is required of observers, and how to start that useful work. It may be added that with care and accuracy much good work may be done.

It has been indicated that the science of meteorology is at present in a state of transition. Two books can be recommended as giving the present state of affairs. One of these is *Climate and Weather*, by H. N. Dickson; the other is *Weather Science*, by Lempfert, in the People's Books. These show clearly where accepted ideas are being questioned, and where they have been confirmed. A book on *Clouds*, as yet unpublished, in the Cambridge Manuals of Science and Literature, will bring that branch of the subject completely up to date.

To keep in touch with the most recent developments some serial publication ought to be read. Mention may be made of two: the *Quarterly Journal of the Royal Meteorological Society*, and the *Journal of the Scottish Meteorological Society*.

The instruments necessary for observational work can be supplied by any scientific instrument dealer.

GEORGE S. DICKSON, M.A., B.SC.

PHYSICS

Scope of Subject.—The science of physics deals with the properties of matter, sound, light, heat, magnetism and electricity. From this we must exclude properties relating to living matter, which is dealt with by biology, zoology, and physiology; we must also exclude the manner in which various forms of matter combine, this being the province of chemistry. On the other hand no definite line of demarcation can be drawn between these sciences. For example, physics deals with the phenomena associated with capillarity in general, whereas the capillary suction of plants has a particular importance to biology and the action of the capillary blood-vessels to physiology; the constitution of matter is a subject of importance both to the chemist and the physicist, whereas the effect of light on living cells is common ground to both chemistry and biology. So with all sciences; they meet and overlap at numerous points, and a discovery of a principle in any one science is sure, sooner or later, to prove of distinct importance to others.

GENERAL PROPERTIES OF MATTER

Divisibility.—A bar of salt can be easily broken into small pieces, and each of these into tiny grains. The same is true of all substances —it is only a question of the force that must be used in order to effect this process of sub-division. Divisibility is therefore a common property of matter. The question now arises as to the extent to which this process can be continued. Evidently, in practice, there is a limit, prescribed by our senses and the instruments we employ for the purpose. But, supposing we were not limited in this way, could we, *theoretically*, continue subdividing any particle of matter, such as a grain of salt for example, indefinitely?

Molecules and Atoms.—The theory of John Dalton (1766–1844), which except for certain modifications, resulting from recent researches, is accepted at the present day, was that we could *not* go on subdividing the grain of salt indefinitely; in the end we should obtain a particle, very minute of course, which would not admit of further sub-division without being changed in nature. This ultimate particle is called a molecule (a "little mass"). If we further subdivide the molecule of salt, the result of the division is no longer salt, but two other substances, viz., sodium and chlorine, which are not in the least like salt either in their appearance or in their properties. A molecule of salt is therefore the smallest particle of salt capable of existing *as salt*, and consists of what is termed an *atom* of sodium in chemical combination with an atom of chlorine. If molecules of sodium or of chlorine are examined it is found that they do not consist of combinations of different substances; the molecule of sodium consists of sodium and nothing else, and that of chlorine contains nothing but chlorine. Substances like sodium or chlorine are therefore termed *elements*, while a substance like salt, which consists of a combination of two or more elements, is called a *compound*. Of the "elements" only about eighty are known, all other substances being combinations of these elements in various proportions. Even the same elements combined in different proportions result in the production of entirely different substances. Consider, for example, the following combinations of nitrogen with oxygen:

In the proportion of 2 to 5 the result is white prismatic crystals.

In the proportion of 1 to 2 the result is an orange coloured liquid (at ordinary temperatures).

In the proportion of 1 to 1, the result is a colourless gas which forms red-brown vapours when in contact with the air.

In the proportion of 2 to 1 the result is a colourless gas which does *not* form red-brown vapours when in contact with air.

The molecule of an element consists of a combination of a number of atoms of the same substance. Thus the molecule of oxygen is composed of two atoms of oxygen; while the ozone molecule is formed by the combination of three atoms of oxygen. Charcoal, graphite, and diamond all consist of the same element, carbon, the differences in their appearance being due to differences in the number of atoms that constitute the molecule.

The molecule of a compound substance, however, consists of a combination of a number of atoms of different elements. Thus a molecule of water contains two atoms of hydrogen combined with one of oxygen; a molecule of sulphuric acid consists of a combination of two atoms of hydrogen, one of sulphur, and four of oxygen, and so on for other compound substances.

Any portion of matter, whether an element or a compound, consists of an enormous number of molecules. These molecules are supposed to be spherical in shape, so that, even when in contact with each other, there exist spaces between neighbouring molecules. Their precise size is not known, but from experiments on soap bubbles and on light, the maximum and minimum limits have been calculated. Some idea of the infinite smallness of a molecule is, however, better obtained from Lord Kelvin's description than from mere figures. His estimate is that if a single drop of water were magnified to the size of the earth, every molecule within it being magnified proportionately, the molecules would then appear, in size, smaller than cricket balls and larger than small shot.

In order to explain the behaviour of gases we must further assume that molecules of all substances are equal in size although they vary in weight, so that a molecule of iron, while equal in size to a molecule of water, is much heavier. Two substances equal in volume will therefore contain an equal number of molecules. This provides a means of *comparing* the weights of molecules of various substances. Taking the weight of a molecule of the lightest known substance (hydrogen) as unity, the molecular weights of other substances have been found in terms of the weight of a molecule of hydrogen.

A few of them are here given (approximate values):

Hydrogen	1
Nitrogen	14
Oxygen	16
Sulphur	32
Sodium	11·5
Zinc	32·5
Mercury	100
Phosphorus	62
Arsenic	150

It must, however, be borne in mind that these molecular weights are only relative, not absolute.

The Three States.—Matter exists either as solid, liquid, or gas. Many substances can exist in all three forms. Water, for example, exists as a solid in the form of ice, as a liquid, and also as a gas called water vapour, and yet it is the same substance in all the three states. The fact that it *is* the same substance in all three states suggests that it is not any change in the molecule of water itself which produces a change in form, but rather the manner in which the molecules are arranged. When the molecules are crowded together very closely the substance is in the solid form; when they are so far separated that each has a separate existence we get the gaseous form; and the liquid form is such that the distances between the molecules is something between these two extremes. The solid, liquid, and gaseous state of matter, is, thus, simply a question of closeness of arrangement of the molecules, and there are states when it is difficult to say whether a substance is a solid or a liquid, or whether it is a liquid or a gas.

Cohesion.—We must further assume that the molecules of any substance also exert an attractive force on each other. The closer they are the greater is this force of attraction, and the greater becomes the force holding them together. This force is termed *cohesion*, and in solids it is so great that considerable force has to be exerted in order to separate one portion from another. Liquids, in which the molecules are further apart, are easily broken up into small drops, and in the case of gases the molecules are already separated to such an extent as to exert no appreciable attraction on each other at all. There is no question of cohesion in gases; a gas will spread out so as to fill every portion of space to which it has access.

Elasticity.—The molecules of any substance can be squeezed together more closely, but they resist this compression, and when the compressing force is removed, will, as a rule, return to their former arrangement. All substances resist and recover from changes in volume, but it is only solids that resist changes in shape. The power of recovery from change in volume is termed *bulk elasticity*, while that from change of shape simply *elasticity*. The elasticity of bodies varies, and a measure of it is obtained from a determination of the force that must be used in order to produce a certain change either in bulk or in shape. The deformation produced in a body is called a *strain*, and the resistance which it offers to this strain is called a *stress*. The elasticity of a body is measured by the ratio $\frac{\text{stress}}{\text{strain}}$.

The subject of elasticity is one of great difficulty, and I will confine myself to the simple example of the stretching of a rubber cord. If a small weight be attached to one end of such a cord, the other end being suspended so that the cord and weight are in a vertical position, the cord will, of course, be stretched. The stretching force is supplied by the weight, and the stretching or deformation of the cord will be such, that the resisting force set up in the rubber (the stress) is just equal to the force exerted by the suspended weight. If we took a thicker cord, one with a cross section twice as great, and suspended the same weight from it, the total stress would still be the same, but as it would be distributed over double the cross section the stress per unit cross section would in this case be only half as great. To measure the stress therefore, the thickness of the cord must be taken into account, and instead of measuring the total stress, the stress *per unit cross section* must be taken as a measure of the stress to which the cord is subjected, so

that, if F represents the total stretching force and A the area of cross section of the cord, the stress is $\frac{F}{A}$. The strain is measured by the deformation, that is by the amount the cord is stretched. Remarks similar to those as regards the manner of measuring stress apply to the measure of strain. The total amount of stretching must not be taken as a measure of the strain; for if we had a cord 1 ft. in length and a certain weight stretched it by 1 in., a similar cord, 2 ft. in length would be stretched by the same weight by 2 ins. since each foot length of the cord gives to the extent of 1 in. under that weight. The measure of strain is therefore not the total elongation, but the elongation per unit length of the cord, so that if L is the unstretched length of the string and L′ the stretched length, the elongation is $L'-L$ and the strain is $\frac{L'-L}{L}$. If we now experiment with the cord we shall find that if a weight w stretches it by an amount l, a weight twice as great, $2w$, will stretch it by an amount $2l$, and a weight $3w$ by $3l$, and so on. We therefore get the relation that the elongation is proportional to the force producing it.

Hooke's Law.—This relationship is known as *Hooke's Law,* and is made use of in the construction of the spring balance, which consists of a steel spiral spring which is stretched by an amount proportional to the weight hung from it, a pointer attached to the end of the spring indicating on a graduated scale the stress to which the spring is being subjected. The same relation (Hooke's Law) is expressed in terms of stress and strain by the statement that "stress is proportional to strain." Since this is the case, the ratio $\frac{\text{stress}}{\text{strain}}$ must always remain the same or constant. Using the above notation $\frac{\text{stress}}{\text{strain}}=\frac{F}{A}\div\frac{L'-L}{L}=\frac{F\cdot L}{A(L'-L)}$. So that whatever the original length or cross section of the cord may be, the elongation $(L'-L)$ under a force F will be such as to give the quantity $\frac{F\cdot L}{A(L'-L)}$ the same value in all cases. This ratio is therefore used as the measure of the elasticity of the substance under investigation. The value of the elasticity thus obtained is termed *Young's Modulus* of the material of which the cord is composed. Let us examine it more closely.

If the cross section A is equal to unity and we applied a stretching force F of such a magnitude that it succeeded in stretching the cord to double its original length, so that $L'=2L$, then Young's Modulus $=\frac{F\,.\,L}{A(2L-L)}=\frac{F\,.\,L}{1\,.\,L}=F$. Hence Young's Modulus *is such a force as will stretch any length of a substance of unit cross section to twice its original length.* And this is true for *any* material, since the mathematical argument is entirely independent of the material used. In practice, of course, no attempt is ever made to stretch a wire or a cord to double its length (it would snap long before that happened). The modulus is found by hanging a weight from a wire composed of the material under investigation and reading the elongation produced. Also the thickness of the wire is measured, and from that the area of cross section calculated. The above formula is then applied.

It should be noted, however, that Hooke's Law only holds within limits. When the *elastic limit* has been reached, any further increase in stretching force will result in an increase in length greater than that indicated by the law, and after a while the length begins to increase very rapidly for small increases in weight until the *yield point* is reached, when the cord will snap; or in the case of metal wires, the wire appears first to *flow* under the forces imposed and then to break. The determination of Young's Modulus, together with the elastic limit and the yield point of various metals, is evidently of the highest importance in the case of metals extensively used in structures where they are subjected to great stresses.

Units.—Use has been made of the term Force in the last paragraph, and we must now examine the meaning of this, together with that of a few other terms, such as mass, density, &c., which frequently occur in physics.

Density and Mass.—The molecules in a piece of iron are more closely packed than those in a piece of wood; they are also heavier. These facts are expressed in scientific language by the statement that "the density of iron is greater than that of wood." Evidently, a denser substance contains more matter than an equal volume of a substance which is less dense. The actual quantity of matter contained in a body is called the *mass* of the body, while the quantity of matter or the mass in unit volume, is termed the *density* of that substance.

The knowledge that the earth attracts every body with a force proportional to the mass of that body, that is to the quantity of matter it contains, supplies us with a means of measuring mass. For example, the earth attracts a cannon ball with much greater force than a cricket ball, and therefore by weighing each we get a measure of the mass of each. The unit of mass is taken, in England, as the quantity of matter in a body weighing 1 lb., or shortly, the unit of mass is a pound. The density, on the other hand, is measured by the *mass in unit volume;* so that if the mass of a body is 6 lbs., and its volume 2 c. ft., the density of the *substance of which that body is composed* is 3.

The question of units now becomes most important, for we can get different answers for the density of the same substance, according to the

units we employ. If in the above example we had expressed the volume in c. inches instead of c. ft., we should have obtained for the density $\frac{6}{3456} = \cdot 001736$ instead of 3. The two answers therefore vary according to the unit of length employed. They would also vary according to the unit of mass employed. The unit of mass, as explained above, is *always* taken as a pound (when the English measure is used), and it cannot be too strongly impressed on the reader that the unit of length *is always taken as a foot* (when the English measure is used) in all physical calculations. It will be found later that the units of all other quantities depend only on the units of length, mass, and time adopted (the unit of time adopted *in all cases is a second*). Consequently the units of these three quantities are called *Fundamental Units*; all other units which are derived from these are called *Derived Units*. For example—an area is obtained by multiplying one length by another length, and the answer obtained for the area of any figure therefore depends on the *unit of length adopted*. The unit used for expressing areas (1 sq. ft.) is therefore a derived unit. A *velocity* is the distance passed over in a given time. If the distance were measured in miles and the time in hours, the unit of velocity would be 1 mile per hour; if the distance is measured in feet, and the time in seconds, the unit is 1 ft. per second. A velocity of 60 miles an hour becomes a different quantity when measured in feet and seconds—it becomes 88 ft. a second. The unit of velocity is thus also a derived unit, depending on the units of length and time.

An *acceleration* is the rate at which a velocity changes. A body whose velocity at one moment is 10 ft. a second, and five seconds later 25 ft. a second, has changed its velocity by 15 ft. a second in five seconds. The rate of change of the velocity, or the acceleration, is therefore 3 ft. a second in each second, supposing the change to be uniform throughout. This is written as 3 ft. sec. sec., the acceleration being said to be uniform. Since the acceleration is found by dividing a change in velocity by the time during which this change has taken place, it is clear that the unit of acceleration involves units of length and time, and is also a derived unit. Many other examples of derived units might be given, but these should suffice.

The fundamental units being a foot, a pound, and a second, this system of units is generally known as the F.P.S. system. It is a system only in use in England, and has many drawbacks. For scientific purposes the French system of units, being a decimal system, has many obvious advantages, and is now universally adopted. In it the units of length, mass, and time are a centimetre, a gramme, and a second respectively, the system being called the C.G.S. system of units. Let us apply these two systems of units to a simple example. A cubic foot of water weighs 1000 oz., or 62·5 lbs., while a cubic centimetre of water weighs 1 gramme. The density of water is therefore either 62·5 or 1 according as we use the F.P.S. system, or the C.G.S. system of units.

Force.—The effect of Force on matter is to cause a body at rest to move (provided the force is sufficiently great), or in the case of a body already in motion, either to increase or decrease its velocity. Force is therefore defined as "that which changes or tends to change the state of rest or of motion of a body." Note the significance of the words "tends to change": if I push against a wall, the force I exert will not change the state of rest of the wall, but it will *tend* to do so.

The effect of Force on matter was fully investigated by Sir Isaac Newton (1642–1727), the greatest mathematician and scientist of his age. He generalised his observations in the three following laws:

1. "Every body continues in its state of rest or of uniform motion in a straight line, unless compelled by impressed forces to change that state."
2. "Rate of change of momentum is proportional to the impressed force and is in the direction of that force."

(By "momentum" is meant the mass of a body multiplied by the velocity with which it is moving.)

3. "To every action there is an equal and opposite reaction."

Forces and their actions, and the application of forces to everyday use, are of such extreme importance, that the subject forms a science in itself (Applied Mathematics or Mechanics). For a fuller study of forces the reader must turn to books on the subject (see pp. 591–592). Here I will content myself with but a few observations. The reluctance of bodies to change their state of rest or of uniform motion in a straight line (Law I) is called "inertia," a property possessed by every material body. The greater the mass of a body the greater is its inertia. "Friction" is the chief force which produces a change in the state of motion of a body: without it, bodies once in motion would continue moving for ever. Rails, wheels, roller bearings, grease-boxes, oiling, &c., are some of the means adopted to reduce friction to a minimum, while brakes, on the other hand, are intended to produce as great a force of friction as possible.

The second law provides us with a means of measuring forces. It must be borne in mind that the law only applies to forces acting continuously, since if the force is at any time withdrawn the body will, according to Law I, continue to move with the velocity it had acquired at the moment the force was withdrawn, assum-

ing, of course, the absence of all other forces, such as friction. If F is the force acting on a body of mass M, and V is the *change* in velocity produced by that force in time T, then the *rate* of change of momentum is $\frac{MV}{T}$, and since the force is proportional to this rate of change of momentum, $F \propto \frac{MV}{T}$ (the sign $\propto$ means "varies as"). But $\frac{V}{T}$ is equal to the acceleration of the body; hence, if A is the acceleration of the body, $F \propto M.A$ or $\frac{F}{M.A}$ = a constant quantity. If the unit of Force is defined in such a way that this constant should become unity, then F will equal M.A. Consequently the unit of Force is defined as "that force which acting on unit mass will produce unit acceleration." By means of this definition $F = M.A$.

What is this unit of Force? Gravity is a Force, and we may hope to obtain our unit of Force from gravity, just as we obtain our unit of mass. The effect of the force of gravity acting on *any* falling body is found by experiment to be such as to produce an acceleration of 32 ft. sec. sec. (in F.P.S. units) or one of 981 cms. sec. sec. (in C.G.S. units). This acceleration is usually denoted by the symbol "g." If the force of gravity which acts on a mass of 1 lb. is F, then $F = 1 \times 32$, so that the unit of force (in the F.P.S. system) is equal to the force of gravity which acts on a mass of $\frac{1}{32}$ lb. This unit is called a *poundal,* and is equivalent to a $\frac{1}{2}$ oz. *weight.*

We are now in a position to appreciate the distinction between "weight" and "mass," terms which are frequently confused. "Weight" is a force, the force with which a body is attracted by the earth, while "mass" is the quantity of matter in a body. A "weight" of 1 lb. is the force with which the earth attracts a "mass" of 1 lb. but the two are not the same. If we could take a mass of 1 lb. to the moon we should find that a spring balance would register its weight as being only about 3 oz. owing to the fact that the moon is a much smaller body than the earth and its attractive power is consequently far less. But the mass would be the same, since the quantity of matter in the body remains the same wherever it may be. Mass is therefore a constant, unchangeable quantity, but weight is not. To avoid confusion, it would be better to say that the force with which the earth attracts a mass of 1 lb. is 32 poundals.

In the C.G.S. system of units, if F is the force of gravity acting on a mass of 1 gm. $F = 1 \times 981$, so that the unit of force is, in this system, $\frac{1}{981}$ gm.—an extremely small quantity. This unit is called a *dyne.* A Force is therefore expressed either in poundals or dynes according to the system of units adopted.

The third law of Force, that action and reaction are equal and opposite, expresses our everyday experience and need not be considered here. We have tacitly assumed it when dealing with the elasticity of a rubber cord—the action of a weight suspended from the cord being such as to produce an equal and opposite reaction in the form of a stress.

Gravitation.—Kepler (1571–1630), a German astronomer, discovered that the path or orbit of every planet about the sun is an ellipse, approximating to a circle. The brilliant mathematical genius of Newton made immediate use of this important discovery. He pointed out that the elliptical orbits of the planets could only be accounted for on the assumption that the phenomenon of attraction was not confined merely to the earth and bodies on it, but was universal. He also demonstrated that the orbit of a planet could only be elliptical if the attraction between the sun and the planet varied inversely as the square of the distance between the two. And since the attraction varies also directly as the masses, we get the universal law of attraction between bodies, viz., the attraction between two bodies of masses m and m' separated by a distance d varies as $\frac{m \cdot m'}{d^2}$. The mathematical expression for this is that the force of attraction $= G \cdot \frac{m \cdot m'}{d^2}$ where G is a constant (called the "Gravitation Constant") and is to be found by experiment. The value of this constant has been found to be ·000000066, an extremely small quantity, which accounts for the fact that, in spite of this law of universal attraction or gravitation, bodies of the size with which we are accustomed to deal do not seem to exhibit any attraction on each other.

Gravity.—"Gravitation" is the word used to express the universal attraction of matter on matter, whereas the term *gravity* is restricted to the force of attraction exerted by the earth. When considering gravity, the distance d in the preceding formula for attraction is to be taken as the distance between a body and the *centre of the earth.* Consequently the attraction of the earth on bodies becomes less the higher we rise. For heights of a mile or so the difference is so small compared with the total distance (the radius of the earth being 4000 miles) as to be quite negligible; but if we could rise to a height of 4000 miles, then the attraction would be quartered, since the distance is doubled, so that a pound weight suspended from a spring balance at that height would only weigh $\frac{1}{4}$ lb.

The acceleration produced by gravity on all falling bodies is usually denoted by the symbol "g," and is a measure of the earth's attraction. The value of "g" at Greenwich (at sea level) is 32·2 ft. sec. sec. or 981·17 cm. sec. sec. The *accurate* determination of "g" is not a simple matter, and any attempt to explain any one of

the many ways in which it is determined would involve an amount of advanced mathematics quite beyond the scope of this work. We must content ourselves with the knowledge that the pendulum method (finding the time of swing of a pendulum whose length can be measured) gives the most accurate results. If the earth were a perfect sphere, every point on its surface would be equidistant from its centre, and consequently the value of "g" would be the same at all places on the earth's surface. Now experiments show that this is not the case; that "g" has a smaller value at the equator than at places north or south of it. The equator must therefore be further from the centre of the earth than places situated to the north or south of it. Determinations of "g" at various places therefore provide us with a knowledge of the precise distance of each place from the earth's centre, and consequently with a conception of the shape of this globe, which is found to be not a true sphere, but flattened at the poles and bulging slightly in the region of the equator. The deviation from the true spherical shape is very small, however, the difference between the polar and equatorial diameters being only 27 miles.

Energy.—If a body be raised from the floor and placed on the table, mechanical work will have been performed in the process, and as a result of this the body will be endowed with *energy*, that is it will possess the *ability to do work*. As long as it is resting on the table this may not be evident, but remove the support given it by the table and allow it to fall and the fact immediately becomes apparent. As long as the body rests on the table the energy is merely stored in it and is called *Potential Energy*, but when it is falling the energy is then said to be *Kinetic*. When a steel spring is wound up work is done in the process, and that work is stored in the spring in the form of potential energy. The moment the spring is released, the energy is released and becomes kinetic. Potential energy may therefore be defined as the energy stored in a body by work which has been previously performed on it, and kinetic energy as the energy possessed by a body in motion.[1]

Conservation and Transformation of Energy.—When the potential energy of a body is released it is found that the amount of work which it can perform is exactly equal to the work that had been previously expended on it—not an erg more or less. In a steam hammer, for example, an engine raises a heavy weight to a certain height; when the weight is released and allowed to fall, the work it can perform is exactly equal to the work that has been done on it by the engine in raising it to that height. On striking the pile, it imparts that amount of energy to it, and so drives it a small distance against certain forces. Throughout all the processes that have taken place—and they are numerous, especially if the manner in which the energy has been produced in the engine is taken into account—not a fraction of an erg of energy is lost. A good deal is wasted, but none lost. The chief source of wastage is in the production of heat, which, as will be seen later, is but another form of energy. In all the above processes one form of energy has been changed into another—heat energy of the engine into mechanical energy or work in raising the hammer, this into potential energy of the hammer in its raised position, then into kinetic energy of motion of the falling hammer, and lastly into mechanical energy in driving the pile. A wastage of energy in the form of heat has accompanied each change, but throughout there is no loss—every bit of it can be accounted for. Similarly the mechanical energy expended in winding a watch is stored as potential energy which, by suitable mechanism, is slowly released and "makes the watch go"; the driving of a nail into the wall is simply conversion of one form of energy into another. Endless examples might be enumerated of the conversion of energy from one form into another, but the principle in every case is always the same, viz.: *Energy cannot be destroyed, although it may be transformed from one form into another.* This is known as the *Principle of Conservation and Transformation of Energy.* Our present methods of converting energy from one form into another are very wasteful. In a ton of coal, for example, there is a sufficient store of energy to enable it to raise a liner weighing 20,000 tons to a height of 500 ft. The present method of utilising this energy, stored in past ages by radiation from the sun, is first to liberate it (by burning) as heat energy and then to convert this into mechanical or electrical energy. Needless to add, only a very small fraction of the total energy contained in the coal is utilised, the rest being wasted in the form of heat. Perhaps the most efficient machine yet discovered (and by efficient is meant the utilisation of energy with the least possible wastage) is the human body, which transforms the energy stored in food into various other forms of energy. As with coal and food, so every form of matter possesses an enormous store of energy. The destructive possibilities of nitroglycerine or gunpowder are well known, and are simply due to the sudden release of their energy. The study of energy supplies us with the key to the behaviour of all forms of matter under certain conditions, and this behaviour is always of such a nature as to *reduce* the energy present in a body or system of bodies whenever conditions will permit of it. Let us consider a few examples. A body falls, because in doing so it gets nearer to the centre of the earth, and thus reduces its

[1] Energy or Work is measured by the product of Force × Distance. The units of Energy are a *foot-pound* (in F.P.S. units) and an *erg* (a dyne × 1 cm.—in C.G.S. units).

potential energy. Hydrogen and oxygen will, under favourable conditions, combine with explosive violence to form water, the result of the combination being a reduction of the energy of the system, the loss appearing as heat; if, on the other hand, we wish to break up the combination back again into its constituents of hydrogen and oxygen, we can only do so by supplying this lost energy, in the form of heat, under suitable conditions. Calcium carbide, which gives acetylene gas on the addition of water, consists of calcium and carbon. When these two substances are brought together, the question as to whether they will combine or not depends on whether the combination will result in a reduction of the total energy of the two. If it will so result then combination will take place, heat, *i.e.* energy, being released in the process; if not, then energy in the form of heat must be supplied in order to effect the combination. Actually carbide is obtained by *heating* lime with coke.

Aluminium is a substance found as an ore combined with oxygen, and it is only by the application of an enormous amount of energy in the form of heat that the two can be separated. According to the principles just described this energy must be given up again when the two elements, aluminium and oxygen, are brought into a favourable position for recombination. This is the essence of *aluminothermics*. A mixture of granulated aluminium and oxide of iron, called "thermit," contains a vast store of energy, and all that is required is to set it free. This is done by placing on the top of the mixture, contained in a crucible, a little quantity of magnesium filings mixed with barium peroxide. A match is lit and thrown into the crucible and instantaneously there lies at the bottom a mass of molten boiling iron at a temperature of 3000° C.—fully 1200° higher than can be obtained in any ordinary furnace. The power which this extraordinary quantity of energy gives to practical men is, needless to say, very welcome, and now finds numerous applications.

Sufficient has been said to indicate the great importance of "energy" in any investigation of natural phenomena. The result may be summarised thus:

(1) Energy may exist in many forms.

(2) Energy of one form may be transformed into energy of another. Our present methods of doing so are very wasteful.

(3) Energy is indestructible.

(4) The behaviour of matter depends on the resulting energy of the system, and is such as to reduce this to a minimum.

Indestructibility of Matter. — Matter, like energy, is indestructible. When a piece of coal is burnt it *seems* to have been destroyed, but if all the gases, ash, and other substances that have resulted from the burning are carefully collected, it is found that their total weight is even *greater* than the weight of the original piece of coal. Far from being destroyed, the coal has merely changed in *form*; instead of existing as coal it now exists as other substances, the increase in weight being due to the addition of oxygen drawn from the air during the process of burning. If water be analysed into its constituents, hydrogen and oxygen, the combined weight of the gases produced is found to be exactly equal to the quantity of water that has disappeared. Water may be "boiled" away, but the weight of vapour produced is exactly equal to that of the water which has apparently been destroyed. There is, however, an important difference between this process and the former one of analysis. In the former, water has been changed into two entirely different substances, oxygen and hydrogen, while in the latter process the liquid has been changed into a gas, the substance remaining the same but merely changing in state. In the first process a "chemical" change is said to have taken place, and in the second a "physical" one. But whatever the change, whether chemical or physical, the result is always the same—*not a single atom of matter is ever destroyed.*

Gases.—Kinetic Theory.—It is a matter of common observation that a gas, however small in volume, will occupy the whole of the space, however large, to which it has access; a gas tap, for example, inadvertently left open for a short time, will soon produce a "smell of gas" all over the house. To account for this, as well as for other facts observed in connection with gases, the assumption must be made that the molecules of a gas are in a constant state of motion, continually encountering each other, colliding, and rebounding again in a chaotic whirl. (The distance through which a molecule moves before it encounters another is called its "free path.") This assumption is known as the *kinetic theory*, and there is reason to suppose that the behaviour of the molecules in a solid or liquid is similar in nature, but in solids the free path is so greatly reduced that the motion of each molecule is of a vibratory nature—a swinging backwards and forwards in a very confined space.

Pressure.—An immediate result of the activity of the molecules of a gas is their bombardment of the walls of the vessel in which the gas is confined, an action which produces a tendency to push the walls outwards. In other words every gas "exerts a pressure," which can be calculated according to Newton's second law, and depends on the mass (m) of the molecule and its velocity (v).[1]

Avogadro (1776–1856), an eminent Italian physicist, enunciated the law that "equal volumes of gases at the same temperature and

[1] The calculation gives the pressure as equal to $\frac{1}{3}nmv^2$, where n is the number of molecules per c.c.

pressure contain equal numbers of molecules." Since the pressure of a gas varies directly as the square of the velocity of its molecules it follows that the molecules of a light gas must possess greater velocities than those of a heavy gas. The hydrogen molecule, for example, being sixteen times as light as the oxygen molecule, will have a velocity four times as great, if both are at the same temperature and pressure. A knowledge of the relative weights of equal volumes of gases therefore provides us with a knowledge of the relative molecular velocities of these gases.

The pressure of a gas is measured by balancing it against another known pressure. For example, if we fill a long tube, closed at one end, with mercury, and invert it over a small trough also containing mercury (Fig. 1), it will be found that the level of the mercury in the tube is from 28 to 31 inches above that of the mercury in the trough. This column is balanced by the pressure of the air on the surface of the mercury in the trough. By weighing the column thus supported and measuring its area of cross section we can calculate the pressure of the atmosphere, which is found to be about 15½ lbs. per sq. inch. This is the principle of the *barometer*, which measures the pressure of the atmosphere by balancing it against a column of mercury, and in scientific language the atmospheric pressure is always expressed in terms of the height of this column of mercury. "Normal" atmospheric pressure per unit area is taken as 760 mms., which means that it is equal to the pressure exerted by a column of mercury 760 mms. in height.

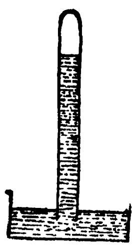


FIG. 1.

Pressure and Volume.—The more gas we crowd into any given space the greater will be the number of molecules impinging on the sides of the vessel in any given time, and as a consequence the greater will be the pressure. *The pressure exerted by a gas therefore depends directly on the density of the gas*, other factors remaining the same. This was first proved experimentally by Robert Boyle (1627–91), as long ago as 1662. He confined a gas in a known space AB (Fig. 2), and balanced its pressure against a column of mercury CD. On raising the tube DE the pressure was increased, with the result that the gas decreased in volume proportionately to the increase in pressure—doubling the pressure halved the volume of the gas, whilst halving the pressure doubled the volume, &c. All gases behave in this way, so that the pressure of a gas multiplied by the volume it occupies, always remains the same. This is known as Boyle's Law, and is expressed symbolically by the equation $PV = \text{Constant}$, where P represents the pressure exerted by the gas, and V the volume it occupies, so that a gas at pressure P and volume V, when subjected to a pressure P', will occupy a volume V', so that $PV = P'V'$.

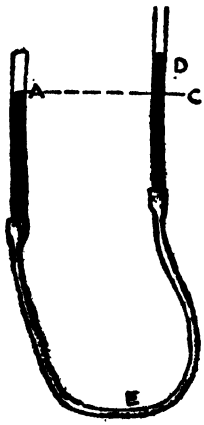


FIG. 2.

If we could produce a sufficiently great pressure, it follows that we should then be able to crowd the molecules of a gas so closely together as to approach the liquid state. At such high pressures, it would not be surprising to find that the behaviour of a gas deviated from Boyle's Law. Now that is precisely what happens when it is tried experimentally. Gases which easily liquefy, such as carbonic acid, cyanogen and ammonia, do not at high pressures obey Boyle's Law absolutely but only approximately, but gases like hydrogen or air, which are at ordinary temperatures far removed from the liquid state, do. Although, therefore, gases do not strictly follow Boyle's Law, we may accept the law as correct so long as the gas does not approach a change in state under the pressure to which it is subjected.

Mixture of Gases.—If in a vessel we have a gas at pressure p_1, and into it crowd another gas at pressure p_2, the result will be an increased bombardment of the walls of the vessel by that amount, and the total pressure exerted by the mixture will be $p_2 + p_1$. In a mixture of gases therefore, *each gas exerts its own pressure*, and one effect of evaporation of water into the atmosphere is to increase the atmospheric pressure.

Pressure and Temperature.—The pressure of a gas is not only affected by the volume which it occupies, but also by the temperature. Fit a glass flask with a cork through which is passed a long, narrow, glass tube open at each end, and into which a drop of coloured water W has been sucked (Fig. 3). The cork and the tube must fit tightly. You now have a volume of air (V let us call it) imprisoned in the flask and tube. If this be warmed slightly—holding the flask in the hand is sufficient—the drop W will rise to some such position as W′. The gas has increased in volume under the action of a slight rise in temperature. Now if it had not been permitted to expand, it would have increased in pressure, since it is under this increase of pressure that the drop W is moved. What has hap-

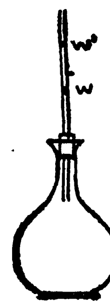


FIG. 3.

pened in the process of heating to result in an increase of pressure? Since the mass (m) of each molecule has not altered, it follows that its velocity (v) must have increased. An addition of heat to the gas has therefore produced an increase in the kinetic energy of motion of the molecules. We are now beginning to see the connection between heat and energy, since heating a gas results in an increase of the energy of its molecules. Evidently cooling, which is the subtraction of heat, would have the opposite effect—that of a reduction of the energy of the molecules and consequently of the pressure exerted by the gas.

Boyle's Law can now be stated fully, viz. The volume of a gas varies inversely as the pressure *provided the temperature remains unaltered.*

Temperature and Volume.—In the last paragraph we have seen that the volume of a gas increases with the temperature. If we arranged our flask experiment so as to be able to take accurate readings, both of the volume of gas we started with and the amount by which this volume had increased, we should find that the gas increased *evenly* in volume by $\frac{1}{273}$ of the volume it occupied at 0° Centigrade, for every degree Centigrade rise in temperature; thus a gas occupying a volume of 273 cubic centimetres at 0° C. would occupy a volume of 283 c.c. at 10° C, and a volume of 263 c.c. at − 10° C., &c., provided the pressure be kept unaltered. (The question of pressure is important, as volume, temperature, and pressure are intimately connected.) This variation of volume with temperature is known as Charles's Law.

Absolute Temperature.—The even diminution in the volume of a gas with fall in temperature is very suggestive. It suggests that if we *could* cool the gas down to − 273° C. it would occupy no space at all—of course long before that occurred the gas would have changed into a liquid and Charles's Law would not hold, but theoretically, if the substance could be kept as a gas it would have no volume at − 273° C. Even theoretically we cannot go beyond this, and hence the inference is that − 273° C. is the very lowest temperature conceivable, and consequently forms a natural starting point or zero from which to measure temperature. It is one actually adopted and called the *absolute* zero—a temperature at which a molecule would possess no energy at all, since its velocity would be zero. It is impossible to conceive of anything colder than this. A scale of temperature starting with − 273° C. as its zero, but otherwise corresponding to the Centigrade scale, is known as the *absolute scale of temperature*, and temperatures expressed in terms of this scale are called *absolute temperatures.* To convert temperatures from the Centigrade to the Absolute scale add 273 to the former. Thus 0° C. = 273° Absolute, and 100° C. = 283° Absolute, &c.

A combination of Charles's Law with Boyle's Law gives the relation that exists between volume, pressure, and temperature of a gas. This is $PV = RT$ where P is the pressure, V the volume, T the absolute temperature, and R a constant to be found experimentally.

Elasticity of Gases.—Just as a compressed steel spring will regain its shape on removal of the compressing force, so a gas will, under pressure, decrease in volume and regain its original volume on removal of the pressure. The behaviour of a gas is therefore similar in character to that of an elastic solid. The elasticity E of a gas is also measured by the ratio $\frac{\text{stress}}{\text{strain}}$ (see p. 623). The stress is the pressure applied (pressure is "force per unit area") and the strain is the change in volume per unit volume, produced by that pressure. Suppose a gas is originally at pressure P and volume V and that a *small* additional pressure p is applied, resulting in a small decrease in volume v, then since the strain is $\frac{v}{V}$, the elasticity E will equal

$$p\Big/\frac{v}{V} = \frac{pV}{v}$$

But by Boyle's Law $PV = (P+p)(V-v)$
$= PV - Pv + pV - pv.$

As both p and v are very small, the product pv of these small quantities may be neglected, and therefore $pV = Pv$.

$\therefore$ E which is equal to $\frac{pV}{v}$ becomes equal to $\frac{Pv}{v}$ which equals P. The elasticity of a gas is thus equal to its pressure P. A gas at high pressure is therefore highly elastic and *vice versa.*

The question of the elasticity of a gas will be found to be of importance in the consideration of phenomena connected with sound.

Structure of Liquids.—The structure of a liquid is similar to that of a gas, but the motion of its molecules is far less vigorous and their "free paths" much shorter. On this assumption, the evaporation of a liquid is due to the escape of a number of molecules from the surface. It is only the faster moving molecules which will succeed in breaking through the surface, those with slower motion being left behind. This will explain the cold produced by evaporation, since as we have already seen, a slower motion of the molecules implies a lower temperature. If evaporation takes place in an enclosed space, that space becomes, after a while, saturated with the liquid vapour and further evaporation apparently ceases; a phenomenon explainable on the hypothesis that at this stage as many molecules are being shot *into* the liquid from the vapour as pass *from* the liquid in the contrary direction.

The molecules of a liquid being much closer

together than in a gas, the attractive force between them is much more intense. This is not apparent at points well within the liquid, since the attraction is there equal in all directions, but in the case of the molecules on the surface there is an attraction inwards, but no counter attraction on the outside, with the result that the surface molecules are pulled inwards, thus producing the same effect as a tight skin. The same is true of solids, but it is not noticeable except when there is contact between a solid and a liquid.

Surface Tension.—All liquids then behave as if the surface were covered by a thin, tightly stretched, elastic skin. The tension of this skin is called the "surface tension" of the liquid. It is due to this tension that the hairs of a wetted paint brush hold together, and that small drops of any liquid are always spherical in shape. Watch drops of water forming at the mouth of a tap. The effect is the same as if a tightly stretched, elastic skin were hanging from the tap and being slowly filled; a drop only breaks away when its weight has become so great that the skin can no longer support it.

If we dip a wire framework such as ABCD (Fig. 4) into a solution of soap and water a thin film will be stretched on it. This film will behave like a tightly stretched skin, and if the bar CD is movable it will contract so that CD moves towards AB. If a force F applied at right angles to CD, supposed to be of length l, will just keep it in equilibrium, and T is the surface tension per unit length, then $2T \cdot l = F$ (2T instead of T since the film has two surfaces, each of which exerts a tension on CD). This equation defines surface tension, which is "a force per unit length."

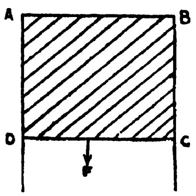


FIG. 4.

The stretched state of the above film implies the presence of potential energy, for if we pull the bar CD a small distance x in the direction of F, the work done or energy is $F \cdot x$, and this additional energy is stored in the film. The increase in potential energy of the film is $2Tlx = 2T \times$ (increase in area of film). Hence the energy in the film *is proportional to its area.*

Why a Drop of Water is Spherical.—The shape which a drop of water assumes is entirely a question of energy. There are two factors to be considered, the energy due to gravity and the energy due to surface tension, and the drop will assume such a shape that the sum of the energies due to these two sources is a minimum (see p. 628). If the drop is small, the surface tension energy is great as compared with gravity, and its shape will be such as to reduce its surface tension as much as possible. This will be effected by the reduction of the surface area to a minimum. It can be proved that for a given volume the sphere is the shape which gives the smallest surface area; hence the drop if small will be round, but if large the question of gravity is the more important factor, and the drop will be flat so as to have its centre of gravity as low as possible. Mercury drops afford splendid examples of the effect of the size of the drop on its shape.

Just as there is surface tension between a liquid and air, so there is surface tension between one liquid and another and between liquids and solids. A drop of oil will spread itself out into a thin film over water, but a drop of water on oil will roll up into a ball. The question as to which will happen is again one of energy. If the surface tension between water and air is greater than the sum of the surface tensions between oil and air and oil and water, the drop of oil will be pulled out so as to cover the water and reduce the surface between the water and air to a minimum, and for the same reason a drop of water on oil will roll up into a ball so as to reduce its surface of contact with air.

Capillarity.—The same effect is observable in the case of a liquid in contact with a solid. Water in a glass is found to be, at the surface edge in contact with the glass, at a slightly higher level than the general level. The surface tension between the glass and air being greater than the sum of the surface tensions between water and air and water and glass, the water in contact with the glass is pulled up so as to reduce as much as possible the surface of glass in contact with the air. In the case of mercury, the effect is reversed, the mercury in contact with the glass edge being depressed *below* the general level (Fig. 5). If a tube of fine bore (a capillary tube) be placed in a vertical position, so that

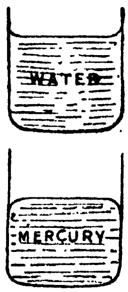


FIG. 5.

FIG. 6.

the lower end dips into a vessel of water, the effect of surface tension is to pull a considerable column of water into and up the tube (Fig. 6). The height of the column will be such that its weight just balances the resultant surface tension force, which may be shown to be equal to that between water and air. This provides one method (of many) of measuring the surface

tension of liquids. For if T is the surface tension, r the inner radius of the tube, h the height of the liquid in the tube above the general level, ϱ the density of the liquid, and g the acceleration of gravity, then the inner circumference of the tube is $2\pi r$, the force of tension at A supporting the column of liquid is $2\pi r\mathrm{T}$, the volume of the liquid column is $\pi r^2 h$, its mass is $\pi r^2 h\varrho$, and the force of gravity on it is $\pi r^2 h\varrho g$.

Hence $2\pi r\mathrm{T} = \pi r^2 h\varrho g$

$$\therefore \quad \mathrm{T} = \frac{\pi r^2 h\varrho g}{2\pi r} = \tfrac{1}{2} rh\varrho g.$$

r, h and ϱ are easily measured; g is known, and hence T can be calculated. For water T is 73 dynes per centimetre.

It is evident both from the last equation and the preceding remarks that the finer the capillary, the higher will be the resulting column. The effects of surface tension thus explain many phenomena; why a sponge, sugar, salt and many other substances which have a capillary structure, suck up liquids; why sap will rise to great heights in trees, apparently defying the law of gravity; why small bodies, such as straw or pieces of cork floating on the surface of water, will when sufficiently close attract each other and collect in clusters, &c.

HEAT

Heat and Temperature.—These two terms are not synonymous. This is shown by the following simple experiment.

If we put a little oil in one vessel, and an equal quantity of water in another, and place them both on the stove, so that they each receive as far as possible equal quantities of heat, the oil will get hot at a quicker rate than the water. A thermometer will show that in the same time the oil has reached a much higher temperature than the water. But as both liquids have received the same quantity of heat in the same time, it follows that heat cannot be the same as temperature. The distinction between the two terms will be clear from the following analogy. If equal quantities of water be poured into two vessels, one narrow and the other wide, the liquid will rise to a higher level in the former. This is precisely the case with temperature, which measures the *level* of heat, not the quantity of heat in a substance. Let us follow the analogy further. If the two vessels containing the water are connected, the flow which ensues is from the vessel in which the water is at the higher level to the one in which it is at the lower, and this flow ceases as soon as the water has reached the same level in both. The direction of flow from one vessel to the other is determined by level and not by quantity. So with heat—a body cools (*i.e.* heat flows from it) when its temperature is higher than that of its surroundings, and the cooling stops when the body has reached the same temperature as that of its surroundings.

The Thermometer.—In devising an instrument to measure temperature, use is made of the well-known fact that heat causes liquids to expand. The usual form of mercury thermometer consists of a bulb connected to a stem through which runs a fine uniform capillary bore. The thermometer is filled by attaching to the end of the stem a small funnel containing mercury. The bulb is then heated, and as it cools some mercury is sucked into the tube. The heating and cooling is repeated until the bulb and part of the bore is filled. The funnel is now removed and the mercury heated until it fills the entire bore, when the end of the tube is sealed in a flame. On cooling, the mercury contracts, leaving a vacuum in the upper portion of the tube. It remains now to graduate the tube. For this three scales are in use—the Centigrade scale (first used by Celsius), the Fahrenheit, and the Réaumur.

Thermometric Scales.—In the Centigrade scale, the freezing point of water or the temperature of melting ice is taken as zero (written 0° C.) and the temperature at which water boils when the barometer is at a height of 760 mms. of mercury, is called 100°. In the Réaumur scale, the same two temperatures are called 0° and 80° respectively, while in the Fahrenheit scale they are 32° and 212°. To graduate the thermometer to the Centigrade scale, it is first placed in melting ice and the level of the mercury in the bore marked 0; the level of the mercury with the thermometer over boiling water is then marked 100, and the distance between these two levels is divided into 100 equal parts and marked accordingly. In the Réaumur thermometer the distance between the above two levels of the mercury is divided into 80 parts, while in a Fahrenheit thermometer into 180 parts (the difference between 32 and 212). The divisions are then continued above and below the boiling and freezing points respectively.

To change from one scale to another is but a simple calculation. For example, let us find what would be the temperature on the Réaumur and Fahrenheit scales respectively, corresponding to a temperature of 15° C.

Since 100° C. is equivalent to 80° R. (Réaumur)

$$\therefore \ 1^\circ \text{ C. is equivalent to } \frac{80}{100} = \frac{4^\circ}{5} \text{ R.}$$

$$\text{and } 15^\circ \text{ C. is equivalent to } \frac{15}{1} \times \frac{4}{5} = 12^\circ \text{ R.}$$

Also since 100 divisions on the Centigrade scale are equivalent to 180 divisions on the Fahrenheit scale,

$\therefore$ 1 division on the Centigrade scale is equivalent to $\frac{180}{100} = \frac{9}{5}$ divisions on the Fahrenheit scale.

And 15 divisions on the Centigrade scale are

equivalent to $\frac{15}{1} \times \frac{9}{5} = 27$ divisions on the Fahrenheit scale.

15° C. is therefore equivalent to 27 Fahrenheit divisions *above freezing point*. And as freezing point on the latter scale is 32, 15° C. must be equivalent to $27 + 32 = 59°$ F.

To change from the Fahrenheit scale to the Centigrade, the calculation is similar, but 32° must first be subtracted. For example 95° F. means $95 - 32$ *i.e.* 63° F. above freezing point, and is therefore equivalent to $\left(\frac{5}{9} \times \frac{63}{1}\right)$° C. above freezing point, *i.e.* 35° C.

In this country the Centigrade and Fahrenheit scales are the ones in common use, and in scientific work the former almost exclusively.

Nature of Heat.—When a piece of iron is filed, both file and iron become hot. The friction involved is a force impeding motion; in overcoming this force mechanical work has to be performed, and it is a matter of common experience that every form of work is accompanied by the production of heat. Thus axles on cars must be greased to reduce the friction; we warm our hands by rubbing them or vigorously moving them; a number of small bodies in space frequently come within the range of the earth's attraction, and, in falling rapidly to the earth through the atmosphere, they are intensely heated by the friction generated, and when this occurs we see a "shooting star."

Our present view as to the nature of heat is based on the molecular theory of the constitution of matter. As already described in the preceding section on Properties of Matter, the molecules of a body are supposed to be in a state of vibration, and their rate of vibration depends on the temperature of the body—the warmer a body is, the greater is the rate of vibration of its molecules, and conversely an increase in molecular vibration manifests itself as heat. When an anvil is struck by a hammer, the kinetic energy of the moving hammer disappears on striking the anvil, but as energy is indestructible the impact has resulted in a "handing on" of the energy of the hammer to the molecules of both hammer and anvil, increasing their rate of vibration and thus raising the temperature. The mechanical energy of the hammer has during impact been transformed into heat energy—and heat energy is nothing but molecular energy.

This conception is known as the Dynamic Theory of heat, but up to the commencement of the nineteenth century, heat was thought to be a fluid called "caloric," the presence or absence of which rendered a substance hot or cold.

Mechanical Equivalent.—The caloric theory held the field until 1849, in which year Dr. Joule of Manchester completed a series of experiments which conclusively proved that *heat is a form of energy*; he further succeeded in actually measuring the relation between heat and energy. One of his experiments consisted in churning water in a copper vessel by a suitable paddle, the paddle being revolved by weights falling from known heights. The heat produced was measured and the energy expended by the falling weights calculated. Joule found that in every case the heat produced was proportional to the expenditure of energy. He repeated his experiments by other methods and used different materials, but always with the same result. There could no longer be any doubt that heat and energy (or work) are so intimately connected that one is but a form of the other. If W represents the quantity of work done or energy expended and H the quantity of heat produced by it, Joule's results may be expressed thus: $\frac{W}{H} = J$ or $W = JH$ where J is a constant value, and is called *Joule's Equivalent* or the *Mechanical Equivalent of Heat*.

If H is unity, then $J = W$, the work done in producing unit quantity of heat. Unit quantity of heat is taken as the heat required to increase the temperature of unit mass of water by 1° C.; in the F.P.S. system this is called a "pound-degree," that is the heat necessary to raise a pound of water by 1° C. in temperature; in the C.G.S. system the unit is the heat required to increase the temperature of 1 gramme of water by 1° C., and is called a *calorie*.

Joule found that 773 foot-pounds of work are the equivalent of one pound-degree Fahrenheit of heat. That is, the work done by 773 pounds in falling through a distance of 1 foot raises the temperature of one pound of water by 1° F. As a result of careful experiments carried out by other investigators (Rowland, Miculescu, Griffiths, Schuster) using various methods and introducing great refinements, the present accepted value of J is, in C.G.S. units, $4 \cdot 19 \times 10^7$ or $(4 \cdot 19 \times 10{,}000{,}000)$, *i.e.* an expenditure of $4 \cdot 19 \times 10^7$ ergs of work or energy will raise the temperature of 1 gramme of water by 1° C.

Thermo-dynamics.—The branch of physics which deals with the relation between heat and work is Thermo-dynamics, the essentials of which consist in two laws. The first law generalises the results of Joule's investigations and is stated thus: "Whenever mechanical energy is converted into heat, or heat into mechanical energy, the ratio of the mechanical energy to the heat is constant." The mathematical expression of this law is the equation $\frac{W}{H} = J$.

Second Law of Thermo-dynamics.—The result of an expenditure of work is an increase in temperature, and according to the principle of transformation of energy, the reverse must hold, viz. we should be able to derive mechanical energy as a result of a decrease of temperature. Although this is true, there is, however, an

important practical limitation. It is a well-known fact that we can obtain mechanical energy by utilising the flow of water, but this is subject to the limitation that when the general level is reached no further flow will of its own accord ensue and no further energy is then available. So with heat; the possibility of a decrease in the temperature of a body, and consequently the derivation of mechanical energy from it, is dependent on the difference of temperature (*i.e.* difference in heat level) between it and its surroundings.

This is the gist of the second law of Thermodynamics, which has been stated in a variety of ways. Maxwell stated it: "It is impossible by the unaided action of natural processes to transform any part of the heat of a body into mechanical work except by allowing heat to pass from that body into another at a lower temperature," while Lord Kelvin's statement of the law is: "It is impossible by means of inanimate material agency to derive mechanical effect from any portion of matter by cooling it below the temperature of the coldest of the surrounding objects."

Let us consider these two laws in a simple application to a steam engine. The energy is originally derived from the coal which heats a substance—water, so as to change it into steam. The steam, in the process of pushing a piston, does work, and consequently must lose heat in accordance with the first law. The steam then passes into the condenser, and as it will not of its own accord cool below the temperature of the condenser, we cannot according to the second law derive any further mechanical effect from it. Consequently the heat with which it will part, and which is available for the performance of work, depends on the difference of temperature between the boiler and condenser. The greater this difference of temperature the higher becomes the efficiency of the engine, or the greater is the work that can be got out of it.

The Effects of Heat on all substances are of a threefold nature: (*a*) to produce an increase of temperature, (*b*) usually to produce an increase in volume, and (*c*) sometimes to produce a change of state from a solid to a liquid and a liquid to a gas. We will consider these effects on the three states of matter in greater detail.

(*a*) *Rise in Temperature.*—This, as we have already seen, depends largely on the substance heated, some substances increasing in temperature on the addition of heat at a much more rapid rate than others. This is true of solids, liquids, and gases. The quantity of heat that must be added to unit mass of a substance in order to raise its temperature by 1° C. is termed the *specific heat of the substance*.

There are many methods employed for measuring the specific heat of a substance, but the following example will illustrate the principle applied in all of them. We wish to find, for example, the specific heat of copper. A small sample of the substance is first carefully weighed—suppose it weighs 20 grms. It is then placed in a "heater," a double walled vessel through the outer chamber of which a stream of hot water or steam is passed. Here it is heated to a known temperature—40° C., for example. It is then quickly transferred to another vessel, called a *calorimeter*, held in readiness to receive it, and in which there is a known quantity of water at a known temperature. Let us suppose that in the second calorimeter we have 45 grms. of water at a temperature of 14° C., and the result of dropping in the copper is to raise the temperature of the whole to 15° C. We are now in possession of all the data necessary to calculate the specific heat of the copper: 45 grms. of water have been heated by 1° C., and have therefore received 45 calories of heat. This heat has been imparted to it by the cooling of the copper, which must therefore have *lost* 45 calories of heat in cooling from 40° C. to 15° C. *i.e.* in cooling through 25° C. If s is the specific heat of copper, then 1 grm. of it in cooling through 1° C. would part with s calories of heat, and therefore 20 grms. in cooling through 25° C. would part with $500 \times s$ calories. And since this is the quantity of heat which the water has gained, $500 \times s = 45$ or $s = \frac{45}{500} = \cdot 09$.

If great accuracy is required, an allowance must be made for the heat gained by the metal of the calorimeter itself, and for the heat lost by cooling during the interval in which the water has been heated from 14° C to 15° C.

The specific heat of a liquid may be found in a similar manner.

The specific heats of a few solids and liquids are here given.

Substance	*Specific Heat*
Water	1·0
Ice	·5
Copper	·09
Iron	·11
Mercury	·03
Petroleum	·51

The specific heat of water in the solid form is seen to be less than in the liquid form. This is generally true of all substances, though not nearly to the same degree as in the case of water. Copper and iron, having very low specific heats, form very suitable materials for vessels in which liquids are to be heated, since little heat will then be wasted in raising the temperature of the vessel itself. For the same reason mercury forms a very suitable thermometric substance, as little heat is absorbed by the mercury itself from any substance whose temperature it is desired to measure.

When the specific heats of gases is investigated

it is found that these vary not only from one gas to another but also with the conditions under which the gas is heated. If the gas is heated and permitted to expand, as it will do, then the pressure of the gas remains unchanged and the heating is said to take place at "constant pressure," but if the gas is not permitted to expand, the volume remaining the same, the pressure will rise, and the heating is then said to be at "constant volume." A gas has therefore two specific heats—the specific heat at constant pressure, usually denoted by the symbol S_p, and the specific heat at constant volume (S_v). When a gas is heated at constant pressure, it expands in spite of the force exerted by the outside pressure (such as that of the atmosphere), and in overcoming this force it does work, which must in consequence result in a loss of heat. If the gas is heated at constant volume, no such work and consequent loss of heat will result. We should therefore expect that more heat would have to be supplied to increase the temperature of a gas when heated at constant pressure than when heated at constant volume. In other words we should expect S_p to be greater than S_v. The following table for three typical gases shows to what extent this expectation is realised by actual experiment:

Gas.	Sp. heat at constant pressure (S_p)	Sp. heat at constant volume (S_v)	Ratio $\frac{S_p}{S_v}$
Air . . .	0·237	0·172	1·38
Carbonic dioxide or carbonic acid gas	0·217	0·173	1·25
Hydrogen . .	3·409	2·402	1·41

(*b*) *Increase in Volume.*—If a bar of iron be heated, its molecules will require more room owing to their increased vibration, and consequently the rise in temperature of the bar will be accompanied by an increase in volume. Considering first the increase in length only—if L is the original length of the bar and L′ the length after an increase in temperature of t degrees, then the average increase in length for each degree rise in temperature is $\frac{L'-L}{t}$, and this expressed as a fraction of the original length is $\frac{L'-L}{Lt}$. This last expression is called the "mean coefficient of linear expansion" of that material, and if the expansion is uniform with each degree increase of temperature it is also the *true coefficient of linear expansion*, which may therefore be defined as "the increase in length of a bar 1 cm. long, when its temperature is raised by 1° C." If we know this coefficient for any material, we can then calculate the amount by which any length of such material will expand on being heated through a given range of temperature. The coefficient of linear expansion is very small in the case of solids, as may be seen from the following:

Co-efficients of Linear Expansions

Brass	0·000018
Copper	0·000017
Iron	0·000013
Gold	0·000015
Glass	0·000008
Silver	0·000021
Zinc	0·000029

Returning to our example of the iron bar, it not only increases in length but in every direction, and the increase in volume for each degree rise in temperature, expressed as a fraction of the original volume, is called the "mean coefficient of cubical expansion." There is a simple relation between the cubical coefficient and the linear coefficient of expansion of a solid. Suppose we had a cube of iron, each edge of unit length, and suppose the increase in length in each direction is l, then each edge becomes $(1+l)$, in length and the volume becomes $(1+l)^3$, which is equal to $1+3l+3l^2+l^3$. As we have just seen, l is, in the case of solids, an extremely small quantity, and therefore $3l^2+l^3$ may be neglected in comparison with $3l$. For example in the case of glass, l being ·000008, $(3l^2+l^3)$ becomes ·000000000192512 while $3l$ is ·000024. The increase in volume per unit volume of a solid is therefore taken as $3l$, or the *coefficient of cubical expansion of a solid is three times that of its coefficient of linear expansion.* In the case of solids it is therefore sufficient merely to determine the coefficient of linear expansion of any substance.

For liquids and gases, however, it is the coefficient of cubical expansion which must be determined, since the quantity $(3l^2+l^3)$ is in such cases too large to be neglected.

In the case of gases the increase of volume with increase of temperature is uniform, and as already stated on p. 630, it is equal to $\frac{1}{273}$ of its volume at 0° C. for every rise of 1° C. in temperature.

The behaviour of liquids under heat is, however, not as uniform as that of gases. Let us take water as an example. If it be cooled from 100° C., it will decrease in volume, thus increasing in density until a temperature of 4° C. is reached. Further cooling now results in an opposite effect to the one we should expect; instead of continuing to decrease in volume, an increase now takes place with a consequent decrease in density, and this continues until solidification sets in, when the expansion becomes still greater during the change from water to ice. On still further cooling the ice behaves as do all solids, by decreasing in volume.

This has important practical effects. During severe weather it is the surface of exposed sheets of water which is cooled first, and as this is accompanied by an increase in density, the surface

water sinks, thus exposing a new surface. This process continues until the whole mass of water reaches a temperature of 4° C. As still further cooling now results in a decrease of density, the surface water remains at the top until frozen. When a sufficiently thick coating of ice has been formed it acts as a very effective "blanket," preventing any further loss of heat on the part of the water below it. Were water to continue decreasing in density below 4° C., the formation of ice would then take place from below *upwards*, so that in severe weather the whole of a lake or river would become a solid block of ice, and result in the death of all fish life therein.

The force exerted by solids, liquids, and gases when expanding or contracting is very great, and has many practical applications. Boilers of steam engines are fitted with "safety valves," so that when the pressure of the steam has reached a certain intensity, the valve is forced open, a quantity of steam escapes, and the pressure within the boiler is lowered. Without such a device the force exerted by the pent-up steam would become sufficiently great to burst the boiler. Water expands on changing into ice, and if contained in a closed iron pipe, the expansion will invariably burst the pipe. (The burst, however, only becomes apparent when the thaw sets in, and the ice in the pipe melts.) It is for this reason that lead piping is used in a water system subject to extremes of temperature—there is more "give" in lead. Metal tyres are fitted on carriage and cart wheels when red-hot, and as cooling takes place the contraction of the tyre binds the wheel firmly together. In joining boiler plates, red-hot rivets are used, and these on cooling draw the plates so closely together as to form steam-proof joints. Walls of buildings which have bulged outwards are drawn into their proper positions in a similar manner; bars are passed through the building and iron plates attached to them outside. The bars are then heated, the plates screwed up tightly against the wall, and contraction does the rest. When railway lines are laid, a space must be left between the ends of any two lengths to allow for expansion. In the construction of clocks, watches, and chronometers intended to keep accurate time the effects of expansion on the time-keeping part of the mechanism (the pendulum or balance wheel) is of great importance, and special devices have to be adopted to counter-balance these effects. This is usually achieved by constructing the pendulum or balance wheel of two metals, in such a manner that the expansion of one is equal to and in a direction opposite to that of the other.

(*c*) *Change of State.*—Another effect of heat is to cause a change of state, from a solid to a liquid, or from a liquid to a gas. The reverse order is produced by the abstraction of heat, or cooling.

If a piece of ice be slowly warmed, and the resulting mixture of ice and water kept well stirred during the process, it will be found *that as long as there is any ice left, no rise in temperature takes place.* This remarkable fact can only be explained on the assumption that the whole of the heat supplied has been entirely utilised in overcoming the forces of cohesion between the ice molecules and thus changing the solid into the liquid state. According to the principles of the convertibility of heat and energy, and the conservation of energy, we should expect the reverse process to take place when the order of change is reversed, and it is found that these expectations are realised. When water changes into ice, a quantity of heat is given out or lost by the liquid during the process of freezing, unaccompanied by any lowering of temperature. This of course tends to check the rate of freezing and is analogous in its action to inertia. Ice is not unique in this behaviour; *all* solids capable of assuming the liquid form behave in the same manner, viz. during the actual process of change from solid to liquid, heat is absorbed unaccompanied by any rise in temperature, and conversely heat is emitted during the change from liquid to solid, also unaccompanied by any drop in temperature.

Latent Heat of Fusion.—The quantity of heat (in calories) thus absorbed in the process of converting unit mass (1 grm.) of a solid into a liquid at the same temperature is called the *latent heat of fusion* of that solid. Values of the latent heat of fusion for a few substances are here given:

Ice .	80·0	Paraffin .	35·1	Zinc . .	28·1
Silver	21·1	Tin . . .	14·2	Sulphur .	9·4
Lead .	5·9	Phosphorus	5·0	Mercury	2·8

It will be seen that in the case of ice, the latent heat is very great indeed. As much heat is required merely to change a quantity of ice at 0° C. into an equal quantity of water at the *same* temperature, as would suffice to heat that quantity of water through 80° C.—nearly to boiling point. On the other hand, the latent heat of lead being very low, that metal quickly melts, and as quickly solidifies again when allowed to cool.

Latent Heat of Vaporisation.—The same phenomenon as the one just described in the case of the conversion of a solid into a liquid, is observed when a liquid is changed into a vapour or gas, during the process of "boiling." Heat has to be supplied, but no corresponding rise in temperature is observed. Boiling water remains at 100° C. in spite of a constant addition of heat. The change from liquid to vapour, is, however, affected to a very great extent by pressure, and the latent heat of vaporisation is dependent upon it.

With water boiling at atmospheric pressure

the latent heat of vaporisation is as high as 536. In other words, to change any volume of water at 100° C. into vapour at the same temperature as much heat is necessary as would suffice to heat more than 5½ times that quantity of water from freezing point to boiling point. When water vapour at 100° C. condenses into the liquid state the same quantity of heat is given out again. It is on account of this, that scalding by "steam" is so serious—apart from a temperature of 100° C., there is, in addition, this great quantity of latent heat emitted.

Pressure and Boiling Point.—The temperature of "ebullition" (or the boiling point) of a liquid depends on the pressure to which the liquid is subjected—the higher the pressure the higher the boiling point, and conversely the lower the pressure the lower the boiling point. Fit up a glass flask over a ring gas burner in the manner shown in the figure. When the water boils, the space above the water will be filled with vapour. Turn off the gas and when boiling has quite ceased squeeze a little cold water from a sponge on to the top of the flask. The effect of this will be to condense some of the vapour, thus lowering the pressure, and immediately the water will be seen to boil again.

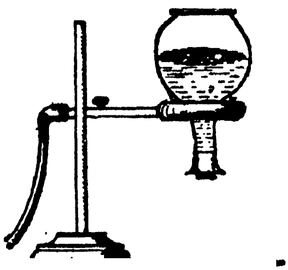


FIG. 7.

Regnault (1810–1878), the great French physicist, investigated this subject in a series of classical experiments, and his results may be summarised thus: (1) The pressure of the vapour formed from a boiling liquid is equal to that under which ebullition takes place; and (2) to every such pressure there is a corresponding temperature at which a liquid boils, this temperature being different for different liquids.

Taking the case of water as an example the following is found:

Pressure in mms. of Mercury	*Boiling point in degrees C.*
4·6	0°
9·1	10°
17·4	20°
31·5	30°
54·9	40°
92·0	50°
148·9	60°
233·3	70°
354·9	80°
525·5	90°
733·3	99°
760·0	100°
787·6	101°
816·0	102°

From this table it is seen that water only boils at a temperature of 100° C. when the atmospheric pressure is 760 mm. Should the pressure drop to 733 mm. it will boil at 99° C. At great heights where the pressure is low, water boils at temperatures considerably below 100° C. The drop in boiling point is approximately 1° C. for every 1062 ft. of elevation above sea level. At the summit of Mt. Blanc water will boil at 85° C. When water is boiled in a closed vessel so that the vapour cannot escape, the pressure will rise, and as a consequence the temperature of both the boiling water and the vapour produced will be raised. This is the principle of Papin's "digester," which is used for the purpose of subjecting articles of food to the action of water at temperatures considerably higher than 100° C.

Evaporation.—It must be borne in mind that the preceding remarks do not apply to evaporation, which takes place at *all* temperatures. Consider, for example, a cubic metre of perfectly dry air, at a temperature of 10° C., in contact with water. Evaporation takes place from the surface of the water, and we have a mixture of air and aqueous vapour, *each exerting its own pressure* (see p. 629). The pressure exerted by the vapour will depend on the quantity of it that is present (see Boyle's Law, p. 629), and evaporation will continue until the pressure of the vapour is equal to that of 9·1 mms. of mercury. The air will then be *saturated*, and no further evaporation will apparently take place. Really a state of equilibrium exists, in which as many molecules of vapour pass into the liquid as pass out of it.

Since no further evaporation takes place it follows that the vapour pressure cannot rise above 9·1 mms., which is therefore the maximum pressure of aqueous vapour at a temperature of 10° C. The rest of the preceding table on this page should be considered from the same point of view, the pressures representing the maximum pressure of water vapour at the corresponding temperature. If now the temperature of our cubic metre of air were to rise to 20° C. it would no longer be saturated, since the maximum vapour pressure corresponding to this temperature is 17·4 mms., and further evaporation would then take place; on the other hand, if the temperature were to drop to 0° C., condensation would take place until the pressure of the remaining vapour drops to 4·6 mms. These facts will be found essential in the consideration of the humidity of the atmosphere.

Graphical Considerations.—If the values as given by the preceding table on this page be plotted on a graph the curve PQ is obtained (Fig. 8), from which can be read the maximum vapour pressures of water at temperatures other than those given in the table.

Thus the point A shows that the temperature corresponding to a maximum pressure of 6·5 mms. is 5° C.; similarly for other points on the curve. Further, the curve forms the line of demarcation

between the gaseous and liquid state of the substance—to the right of the curve the conditions as regards pressure and temperature are such that the substance can only exist as a gas, while to the left they are such that it can only exist as a liquid; on the curve itself the conditions represent a state of equilibrium, both liquid and vapour being capable of existing in contact with one another without any alteration of their relative proportions. Water under the directly into vapour without passing through the intermediate liquid state—a process called "sublimation." The ice-line being parallel to the pressure axis, shows us that no amount of pressure alone will change water into ice, for if we consider the liquid as represented by any point such as F, increase of pressure alone will merely carry us along the line FS, parallel to PG, which would therefore never be crossed.

It is obvious that at P, the three states—solid,

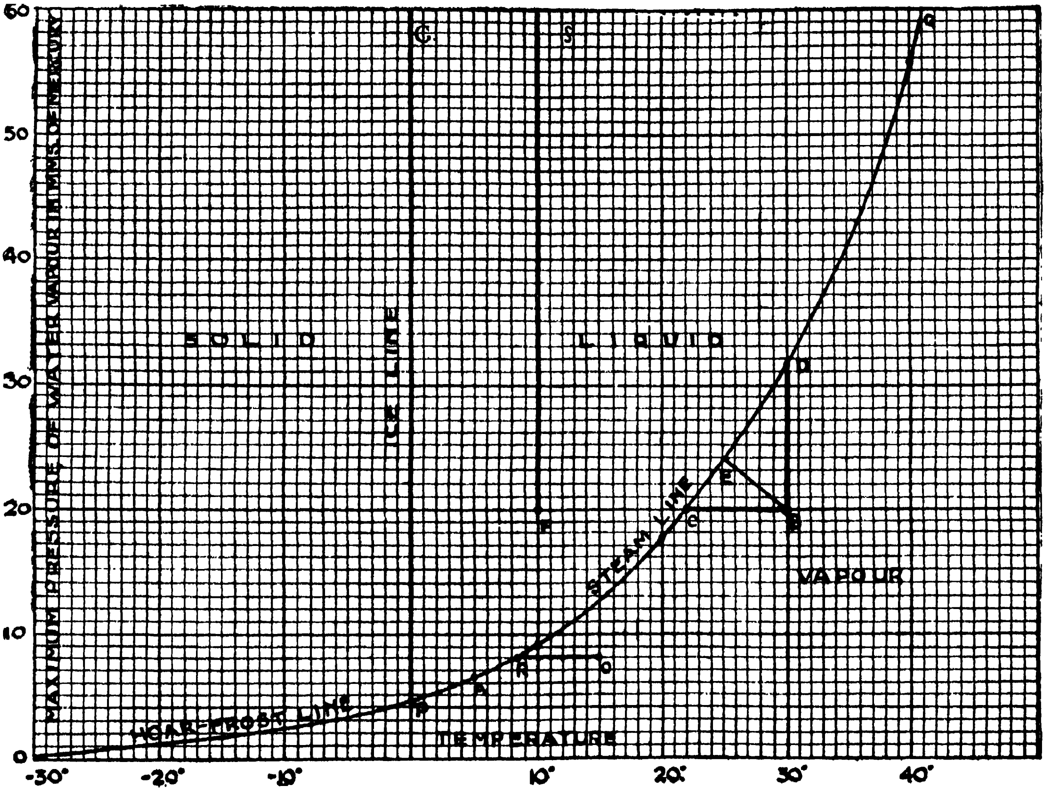


Fig. 8.

conditions represented by the point B, viz. pressure 20 mms. and temperature 30° C., would exist as vapour; to change it to a liquid we may either reduce the temperature to slightly below 22° C., when the change would be represented by the line BC, or increase the pressure to slightly above 31·5 mms. when the change would be represented by the line BD, or both reduce the temperature and increase the pressure simultaneously as would be represented by a line such as BE.

Similarly the line PG—called the "ice line" —represents conditions of equilibrium between the liquid and solid states, while the curve QP produced to O ("hoar-frost" line) gives the conditions under which the solid will change liquid, and gas—can coexist in equilibrium. P is therefore called the *triple point*.

Liquefaction of Gases.—Curves exactly similar to the last can be drawn for gases other than water vapour, and we are now on the track of the conditions necessary to enable us to liquefy gases, conditions which were not understood until 1863. The reader who is acquainted with the nature of curves will at once realise that the curve PQ of the last figure is "asymptotic," which means that beyond a certain point it becomes parallel to the pressure axis as shown in Fig. 9. That being the case, it follows that, as in the case of change from liquid to solid, it is impossible to convert a gas into a liquid by high pressure alone as long as the temperature

remains higher than that indicated by the dotted line in Fig. 9. At a temperature lower than this, however (conditions represented by the point G for example), increase of pressure alone will be represented by GL, which ultimately crosses the curve, indicating that the substance has attained the liquid state. This temperature, to which a gas must first be cooled, is called the

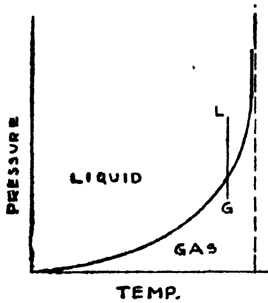


FIG. 9.

"critical temperature" for that gas, and unless a gas is first cooled to its critical temperature, no pressure, however intense, will produce liquefaction. The pressure that must be applied at the critical temperature is termed the "critical pressure." Both critical temperature and critical pressure vary for different gases, as is shown in the following table:

Gas.	Critical Temp.	Critical Pressure in Atmospheres.
Water	365° C.	195·0
Sulphur dioxide	156° C.	78·9
Carbon dioxide	30·9° C.	77·0
Oxygen	-118° C.	50·0
Nitrogen	−146° C.	33·0
Hydrogen	−234° C.	20·0

It is also clear from the curve that the more a gas is cooled below its critical temperature the smaller is the pressure required to convert it into a liquid. Water, for example, if cooled to slightly below 100° C. will liquefy at atmospheric pressure, but at its critical temperature of 365° C. a pressure of 195 atmospheres is required. An examination of the table will also make it clear why the gases oxygen, nitrogen, and hydrogen have for so long defied liquefaction. Although it is easy to produce high pressures it is very difficult indeed to produce the low temperatures necessary in the case of these gases. It was not until 1898 that Professor Dewar succeeded in liquefying hydrogen. The liquefaction of air involves the use of most elaborate machinery, but its production in any quantity is now merely a matter of expense.

Humidity.—The remarks on p. 637 make it clear that the humidity of the atmosphere, or feeling of "dampness," does not depend on the actual quantity of aqueous vapour in the atmosphere but on how near that quantity is to the saturation point, which in turn depends on the temperature. Or, looked at in another way, the humidity depends on the pressure p exerted by the vapour actually present at the time, compared with the maximum pressure P which the vapour *would* exert at the existing temperature if saturation point had been reached. *Humidity* is therefore defined as the ratio $\frac{p}{P}$. Direct measurements of p and P are not possible, but are obtained indirectly by the aid of an *hygrometer*, an instrument by means of which the temperature of the air in its neighbourhood is lowered until dew is formed on a glass bulb; the hygrometer also contains a thermometer to read the temperature at which the dew is formed.

Hygrometry—Dew Point.—To illustrate the method I will take a concrete example. Suppose the existing temperature to be 15° C. and dew formed on the hygrometer at 8° C. The latter temperature is then termed the *dew point*, this being the temperature at which the atmosphere would be saturated by the vapour actually present. What has taken place? We had aqueous vapour at a temperature of 15° C. and an unknown pressure p. Reducing the temperature to 8° C. has not altered the pressure p, but we find that at 8° C. the equilibrium state is reached, which is represented on the curve on p. 638 by the point R. The cooling process is therefore represented by the line RQ in the *reverse direction*, the starting point being Q, corresponding to a temperature of 15° C. Having found Q we now have all the data necessary for calculating the humidity. The curve gives us the actual pressure p corresponding to Q as 8 mms. and also the *maximum* pressure P corresponding to Q as 12·7 mms. The humidity is therefore $\frac{8 \cdot 0}{12 \cdot 7} = \cdot 63$. It should be noted that a humidity equal to 1·0 means saturation point or dew point, resulting in condensation in the form of rain the moment there is a slight drop in temperature. We can now see why the presence of hills or mountains in a district produces a greater rainfall than would otherwise be the case. The air, laden with water vapour and moving with the wind, is deflected in an upward direction and consequently to cooler regions by the hills. If the air is near saturation point, a very small drop in temperature is sufficient to cause condensation of some of the water vapour it contains.

Transference of Heat.—We know that heat is transferred from place to place. How is this accomplished? If one end of a poker be placed in the fire, the other end too gets hot in time, the heat being handed on from particle to particle, the warmer molecules heating the neighbouring colder molecules. This is the process

of *conduction*. In the case of a liquid or a gas, however, the portion nearest the source of heat moves bodily away, thus leaving room for other colder portions of the liquid or gas to get nearer the fire and be heated in their turn. This method of propagation of heat by the movement of the substance itself is termed *convection*.

Besides those two there is still a third manner in which heat is transferred from place to place, and that is the manner in which we daily get our heat from the sun. There is no matter to act as a medium between the sun and ourselves either to conduct or to convect the heat to us. The manner in which the heat does reach us is called *radiation*, and is similar in manner to that in which light travels. It is a form of wave motion which will be described in the next section on Sound and Light.

Conduction.—A piece of iron always feels colder than a piece of wood although they may both be at the same temperature, because the iron in contact with the hand conducts the heat away from the hand at a *quicker rate* than the wood. Iron is therefore a better conductor of heat than wood. The conducting power or *thermal conductivity* of any substance is defined as the quantity of heat which in 1 sec. passes through a slab of that substance 1 cm. thick and 1 sq. cm. in cross section, when the temperatures of the two faces differ by unity.

Thermal Conductivities (in calories)

Silver	1·53	Lead	0·12	Alcohol	0·0004
Copper	1·00	Mercury	0·015	Cork	0·0007
Gold	0·72	Marble	0·005	Air	0·00005
Brass	0·32	Ice	0·005	Horn	0·00009
Zinc	0·26	Glass	0·002	Carbon dioxide	0·00003
Iron	0·16	Water	0·001		

It will be seen from this table that the metals form the best conductors of heat, and of these silver is the best of all. Liquids are very poor conductors and gases still more so. In both liquids and gases, heat is propagated by the convection process, conduction playing but a negligible part. The conductivity of ice being as low as ·005 explains why that substance forms such an effective protection to any water beneath it against loss of heat at any appreciable rate.

Effects of Conduction.—The warmth due to the clothing we wear, to bedclothes, &c., is a direct result of the low conductivity of the material used for these purposes, the heat of the body passing through them very slowly. Since the conductivity of air is very low indeed, clothes that fit fairly loosely so as to leave a layer of air between them and the skin are warmer than those that fit tightly.

If a piece of copper wire gauze be held close to and above a gas jet and the gas be lit on the side of the gauze furthest from the jet, it will be found that the gas below the gauze will not light, the copper conducting the heat away from the neighbourhood of the gas sufficiently rapidly to lower the temperature below that necessary to cause the gas to ignite. The Davy lamp depends on this principle: in it the flame is completely surrounded by wire gauze, and any explosive gases in the mine will penetrate to the flame and burn inside the gauze, but the flame cannot pass through to set fire to the gases outside, and the explosion that would be produced by a naked light is thus averted. The burning of the gases inside the gauze also serves to indicate the dangerous state of the atmosphere. It should be added, however, that the Davy lamp is not an efficient protection in *all* cases.

Convection in liquids and solids is due to the expansion produced in them by heat, which causes the portion nearest the source of heat to become less dense and therefore to rise. All systems of ventilation depend on this principle of establishing convection currents. Winds, land and sea breezes are largely convection currents set up by unequal heating of the atmosphere. A number of ocean currents are also due to convection, the cold water of the arctic regions flowing as an undercurrent towards the equator, while the warm surface water from the equatorial regions flows towards the poles. The system of heating buildings by hot-water pipes is but an application of convection. The water in the boiler rises through the outflow pipe situated at its highest point, circulates round the network of pipes through the building, and returns by a pipe which enters the boiler at its lowest point. The transmission of heat by this system involves all three processes—conduction, convection, and radiation. The heat passes through the boiler plates to the water by conduction, is transmitted through the boiler itself and the building by convection, passes through the pipes by conduction, and the air in the room is warmed by convection. Heat is also *radiated* directly from the pipes to the objects in the room.

Radiation.—Radiant heat is similar to light, not only in the manner in which it is propagated, but also in its behaviour. When radiant heat falls on a body, part is absorbed by the body with a consequent rise in temperature, part is reflected in a manner similar to that in which light is reflected from a mirror, and part passes through, as light does through glass. The proportions in which the heat is absorbed, reflected, or transmitted varies of course with different substances. Substances which transmit a good percentage of the heat are said to be "diathermanous" while those that do not are "adiathermanous." Rock salt is the most diathermanous substance; it transmits about 90 per cent. of the heat incident upon it. The behaviour of glass in this respect depends on the source; it transmits about 50 per cent. of the radiation from a source at a high temperature such as solar radiation, but

is almost adiathermanous to radiation from a source at a temperature below that of a red heat. Hence the use of glass in hot-houses—it is diathermanous to the sun's rays, but adiathermanous to radiation from within. The aqueous vapour in the air acts in a similar manner—it screens the earth from the intense heat rays of the sun, and also lowers the rate of radiation from the earth during the night. In deserts where little aqueous vapour is present the days are intensely hot and the nights extremely cold.

Radiation is also responsible for the formation of dew. Substances which radiate well cool quickly, at the same time lowering the temperature of the air in immediate contact with them until the dew point is reached (p. 639). Any further cooling then results in a deposition of water vapour in the form of dew. It is evident that the most favourable conditions for a copious deposition of dew are: (*a*) a clear sky—the presence of clouds lowers the rate of radiation; (*b*) a calm state of the atmosphere, so that the air in contact with an object may remain in position sufficiently long to be cooled below the dew point; (*c*) the objects on which dew is formed must be good radiators, and must be situated near the ground; if some distance from the ground, the air in contact will, on cooling, sink, and its place will be taken by warmer air, and thus the dew point will never be reached.

The *bolometer* is a very sensitive instrument invented and used by Professor Langley for the detection and measurement of radiant heat energy. It is based on the principle that the electrical resistance of a conductor changes with the temperature (see p. 659).

SOUND AND LIGHT

Introductory.—If an electric bell be fitted up so as to ring under the receiver of an air pump, it will be found that as the receiver is being exhausted of the air which it contains, the sound of the bell becomes fainter and fainter, and if the exhaustion is carried sufficiently far, the bell will not be heard at all although the hammer can be seen striking. Evidently therefore, the presence of the air is necessary for the transmission of sound. Similar experiments demonstrate that all gases transmit sound. Not only gases, but all liquids and solids possess the same property—the ear, placed to the road, will detect the sound of a vehicle a long way off which could not be heard in the ordinary way. We are therefore led to the conclusion that sound can only be propagated through the medium of matter, and we will proceed to consider the manner in which this takes place.

Wave Motion.—If a tuning fork be struck, the ends of the prongs are seen to vibrate in a direction perpendicular to their length. Unless they do so vibrate, no sound is heard. Similarly a bell, or any other body emitting a sound, vibrates. The vibration is a necessary antecedent to the production of any sound, and is communicated to the air in the following manner.

Let us take the tuning fork as an example and concentrate our attention on one prong only. As this, in the course of its vibration, moves to the right and left of its mean position of equilibrium, it naturally affects the state of the air immediately in contact with it. If the movement (to the right let us suppose) were a slow one, it would simply move this air bodily away out of its path, but as it is a very rapid one, so rapid that a few hundred vibrations are repeated in one second, and the air, like all matter, possesses inertia, the result is a compression of the air in immediate contact with the fork. The prong then quickly moves to the left, leaving in its place a partial vacuum or a *rarefaction* which would be quickly filled in by the surrounding air, but for the fact that the motion is so rapid that there is no time for this to happen before the fork moves back again to the right.

The even distribution of the air to the right of the prong before the fork was struck is repre-

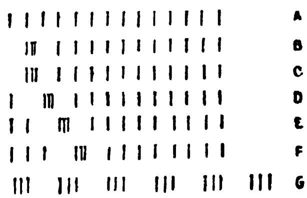


FIG. 10.

sented in the accompanying figure (row A) by a series of lines at equal distances from each other. The compression produced by the motion of the prong to the right is represented in row B by the crowding together of a few lines, while the rarefaction resulting from the movement of the prong to the left is represented in row C by the greater separation of the lines. As a result of one vibration of the prong to right and left of its mean position there exist therefore, a compression and a rarefaction of the air immediately to the right of the prong.

Now owing to the elasticity which the air possesses, the compressed portion at once expands, and in doing so it both compresses the air immediately to the right of it and fills up the vacuum on its immediate left. This produces a rarefaction where previously there was a compression, and passes the compression on towards the right (row D of figure). This process is continued as shown in rows E and F. By the time the compression has thus passed on a very short distance from the fork, the prong will again have repeated another movement to the right, and have produced another compression, which in its turn is sent following in the tracks

of the first. This is repeated very many times in a second, so that immediately after the fork is struck there is a series of compressions travelling away from the fork, with a rarefaction between every two successive compressions, as shown in row G. Of course it must be understood that precisely similar processes take place to the left of the prong, although for the sake of simplicity I have confined myself to a description of the changes in one direction.

This process constitutes a *wave motion.* The following simple experiment may help the reader to see in a more concrete form the nature of the process just described. Place a number of pennies or halfpennies in a row on the table and in contact with each other; move the one at one end a short distance from the row and jerk it smartly forward so as to hit the edge of the coin next to it. This movement will be transmitted right through the row and the coin at the further end will be jerked away. It will be noted that the positions of the other coins remain quite unchanged. The jerk has produced a slight compression of the coin hit; this compression has been passed on to the next, and on throughout the row until the last coin is reached, and this, being free to move, is jerked forward. This is an exact reproduction of what happens in the case of the tuning fork and the air, the sharp movement of the prong taking the place of the jerk. Although the wave of compression travels forward, the positions of the particles of air themselves remain unchanged, except for a small vibratory movement to right and left in the direction in which the wave itself is travelling. The vibratory motion of the air particles is exactly similar to that of the vibrating prong, and must not be confused with the wave of compression itself, which is ever travelling forward in a straight line.

Longitudinal and Transverse Wave Motion.—The wave motion just described, in which the particles of the vibrating medium possess a small vibratory motion in the *same* line as that in which the wave itself is travelling, is called a *longitudinal* wave motion. If a stone be dropped into a pond, circular waves are seen travelling away outwards from the spot where the water was struck, but in this case the wave motion is not longitudinal, for if a cork be floated on the water, it will be seen to move up and down, showing that the particles of water themselves are moving vertically up and down, whereas the wave is travelling in a horizontal direction. The particles of the vibrating medium are in this case moving in a direction perpendicular to the line of motion of the wave itself. Such a motion is called a *transverse* wave motion.

How we Hear.—When a body is vibrating so as to transmit longitudinal waves through the air in all directions, and when a series of these waves falls on the ear, a membrane within it called the *tympanum*, is set vibrating in unison, and produces the sensation of sound. It is found experimentally that a rate of less than about sixteen vibrations a second will not produce an audible sound however close to the ear the vibrating body may be. On the other hand the structure of the ear does not seem sufficiently delicate to respond to vibrations produced at a rate greater than 35,000 in a second.

The Ether.—Just as sound is transmitted from a vibrating source to the ear by means of a longitudinal wave motion of the intervening medium (the air), so light is transmitted from a luminous source to the eye by means of a transverse wave motion. But a wave motion of any kind necessarily implies the presence of a vibrating medium, and since light reaches us from the sun and stars through space in which there is no matter, scientists have been compelled to assume the existence of a medium which fills all space—a something, called *ether*, sometimes luminiferous ether (light-carrying ether), which is capable of transmitting the wave motion produced by a luminous body. Although this substance, if it can be called a substance, has its origin only in the mind of man and cannot be directly apprehended by our senses, even with the aid of any existing instruments, yet its properties are well known from the effects produced by it. Thus, in order to be capable of transmitting a wave motion it must possess both elasticity and inertia (which implies density). On the other hand it must be of such a nature as to offer no resistance to moving bodies, otherwise the rotations and motions of the planets would be affected by it.

Further, since light can be transmitted through various substances—solid, liquid, and gaseous—the ether must even pervade the very spaces between the molecules of matter. The universe must therefore be conceived as a sea of ether which has penetrated the very structure of all matter, and in which the heavenly bodies are immersed but through which they move unimpeded by it—a sea which directly connects us with the sun, whose energy is being constantly dissipated into it, and through which an infinitesimal portion of this energy reaches us and supplies the means whereby life, in all its myriad forms on this planet, is maintained and perpetuated.

Nature of Light.—The cause of the ethereal vibrations which constitute light was not understood until Clerk Maxwell in 1873 published his electro-magnetic theory. His study of electrical displacements or waves, led him also to the necessity of assuming the existence of a medium for the propagation of these waves—a medium possessing properties exactly similar to those of the ether just described, and which must therefore be identical with it. When he further found that the velocity with which electrical

waves travelled through the ether was equal to the velocity of light, he concluded that light must be the result of some such electrical waves. At first his theory received very little support, but since then, the mass of evidence in this direction has become so great, that his theory is now universally accepted. There are many reasons for supposing that there exist in the atoms of all substances minute negatively electrified particles, very many times smaller than the atom itself, which revolve in small orbits within the atom (see Electron Theory, p. 669), and that as a result of the oscillations of these "sub-atoms," called *electrons*, electro-magnetic waves are produced and propagated through the ether. When the energy of the atom—or, to be more precise, the rate of vibration of the electrons—is increased by a high temperature, the nature of these electro-magnetic waves is such as to fall within the limits of perception of certain of our sense organs, and to produce the sensations of light and heat.

Wave-Length—Amplitude.—A study of wave motion shows that the distance between two successive compressions remains constant throughout the motion. This distance is called a *wave length.* Taking the case of the tuning fork again, the wave length evidently depends both on the frequency with which the prong returns to the position which produces a compression, and on the velocity with which these compressions travel away from the fork.

The distance through which each particle of the medium moves in the course of its oscillation or vibration, whether this be in the direction of the wave motion (as in a longitudinal wave motion) or in a direction perpendicular to it (as in a transverse wave motion), is called the *amplitude* of the vibration. The amplitude, unlike the wave length, does not remain constant, but decreases with distance from the source of disturbance.

Every wave motion is characterised by a definite wave length and amplitude. The wave length determines the quality of the resulting sensation—pitch (*i.e.* a high or low note) in the case of sound, and colour or heat in the case of ethereal wave motions; the amplitude determines the intensity (loudness or softness, brightness or dullness, &c.) of the sensation. Thus the wave length of the air disturbance giving rise to the musical note C is greater than that resulting in the note G; the sensation "red" differs from "blue" only in so far as "red" is the result of an ethereal disturbance of greater wave length than that producing the sensation "blue"; the sensation of heat felt *directly* from a fire is due to ethereal disturbances of still greater wave length than those producing light. As long as a sensation is perceived at all, its quality, being dependent merely on wave length, remains unchanged whatever the distance of the observer from the source—"red" remains "red" whether seen at a distance of a foot or at a distance of ten yards. Not so, however, as regards the intensity of a sensation.

Mathematical treatment shows that the amplitude of a wave motion decreases as the square of the distance from the source. Consequently all sensations resulting from wave motions decrease in intensity with the square of the distance. The sound heard by a person A, stationed at a distance twice as great from the source as another person B, is only one-fourth as loud as that heard by B; if I move from the fire to a point three times as distant as that previously occupied, the direct radiant heat that I will feel will only be one-ninth as intense; if the intensity of illumination on a piece of paper placed at a distance x from a light, is called "one," the illumination on that paper when moved to a distance $2x$ will only be one-fourth, &c.

To sum up—Sounds are due to the vibration of the air, and all the sounds to which we are accustomed are essentially air disturbances of the same type but differing in wave length and amplitude. Radiations, on the other hand, whether consisting of light (of whatever colour), heat, or electrical waves (of the kind known as wireless), are the result of ethereal vibrations, and are differentiated from each other merely in wave length and amplitude. Our sense organs, the ear, eye, and skin, are remarkable instruments—far more wonderful and delicate than anything yet produced by man—for detecting and differentiating these aerial and ethereal wave motions.

Velocity of Wave Motion.—If l represents the distance between one compression and another, or the wave length, and n the number of these wave lengths which pass any fixed point in a second, it is evident that the velocity v with which a wave motion travels, is given by the equation $v = nl$: n in this equation is called the *frequency*, and must be equal to the number of compressions produced by the vibrating body in a second, or to the rate of vibration of the body itself. Thus in the case of a tuning fork vibrating 256 times a second the frequency of the resulting wave motion is 256, and this is the number of waves which must enter the ear every second in order to produce the sensation of the note emitted by the fork.

Newton proved that the velocity v with which a wave motion travels through any medium is given by the equation $v = \sqrt{\frac{E}{d}}$. In this equation E represents the elasticity and d the density of the medium. Now the equation $v = nl$ might have led us to think that v depends on n and l, but the equation $v = \sqrt{\frac{E}{d}}$ shows that this is not so, that v is simply dependent on the pro-

perties of the medium as regards elasticity and density and therefore must have a constant value for any particular medium; n and l will consequently have such values that in any given medium their product remains constant and equal to the velocity v of the wave motion in that medium. The greater the frequency n, the smaller must be the wave length l and *vice versa.* Very rapid vibrations will therefore result in the production of a wave motion of small wave length, and conversely slower rates of vibration will give rise to longer wave lengths. A disturbance may therefore be described either as of a high frequency or of a small wave length, indifferently. For similar reasons, all radiations, whatever their nature, will travel through the ether of space with the same velocity. It is found, however, that this velocity is diminished during the passage of radiant waves through matter—the velocity of light through air is less than through space and through water still less. We are therefore forced to conclude that the properties of the ether pervading matter are in some way modified as compared with those of the free ether of space.

The *velocity of sound* in air has been measured in many ways, and found to be 330 metres or 361 yards a second. If the velocity is calculated from the formula $v=\sqrt{\frac{E}{d}}$ [illegible] $\sqrt{\frac{\text{pressure}}{\text{density}}}$ (since the elasticity of a gas is equal to its pressure—see p. 630), the result, at usual atmospheric conditions, is found to be 280 metres a second. This large discrepancy between the experimental and calculated results remains to be accounted for.

The air as a result of its vibrations, gets heated, and as those vibrations are very rapid there is no time for the heat to be dissipated. Now the effect of heat on a gas is to increase the pressure; hence the very motion itself alters the conditions under which it is propagated, so that they are different from the observed conditions. A correction must therefore be applied to Newton's formula, and Laplace (1749–1827), a great French mathematician, showed that this correction should be $v=\sqrt{\frac{kP}{d}}$ where k is the ratio of the two specific heats of the air (see p. 635) and P the observed pressure. Applying *this* formula the result is 332 metres a second for the velocity of sound in air, at usual atmospheric conditions. This agrees so closely with experimental results as to be a proof of the accuracy of the assumptions on which the formula is based.

The known velocity of sound in air enables us to calculate the wave length of a note of known frequency by means of the equation $v=nl$. Thus the wave length of a note emitted by a fork vibrating at the rate of 256 times a second will be found to be about 4½ ft. in length.

Not only for air, but for all gases the velocity of sound is equal to $\sqrt{\frac{kP}{d}}$. In the case of liquids and solids, however, the effect of small changes of temperature on elasticity is so small as to be negligible, and the formula $v=\sqrt{\frac{E}{d}}$ is applicable. Sound travels through water at a rate more than four times as fast as through air; in solids the velocity is more rapid still—in cast iron, for example, it is 10½ times as great as in air.

Doppler's Principle.—The pitch of a sound, as has already been remarked, depends on the frequency of the vibrations. This is well illustrated in the case of a note produced by the whistle of an express train as it approaches and recedes from a stationary observer. We may imagine the train to be stationary and the observer moving towards the whistle with the speed of the train—the relative effect will be the same. In doing so he will have *met* a number of waves proceeding towards him and so his ear will, in a second, have received a certain number of vibrations above and beyond that produced by the whistle, with the result that the note sounds higher than the one actually emitted. The opposite effect is produced as the train recedes from him, a certain number of vibrations being lost per second, and the pitch of the note dropping in consequence.

The same principle, known as *Doppler's Principle*, holds also for light, but the velocity of light is, as we shall see later, so very great, that it requires a velocity of many miles per second on the part of a moving luminous body to produce any change, capable of detection, in the character of the light. These high velocities are, however, found in the case of the heavenly bodies, and the application of Doppler's Principle makes it possible for the astronomer to perform the apparently hopeless task of determining the velocity with which a star is moving directly away from him. The speed with which the sun rotates about its axis is found in a similar manner. Since one limb is, owing to this axial rotation, moving towards us and the other limb away from us, an examination of the difference in the character of the light given by the extreme ends of the sun's disc enables us to calculate the required velocity.

Noise and Music.—A noise is the result of an irregular succession of waves, continually changing in character as regards frequency, while a musical note is caused by vibrations which strike the ear at definite and unaltered rates. *Melody* consists in a succession of musical notes, while *harmony* is a simultaneous sounding of a number of notes which combine and blend, so as to produce a pleasing effect. In both melody and harmony the ear is sensitive neither to the actual frequencies of the notes nor to the differ-

ences between those frequencies, but to their *ratio*, which is called an interval. Between a note and its upper octave this ratio or interval is one-half, the frequency of the octave being exactly double that of the given note.

The Human Voice.—Vocal sounds are produced by the vibration of two stretched membranes known as the *vocal cords*, whose tension is regulated by muscles attached to them. They are situated across a tube leading to the lungs, called the *trachea*, and are made to vibrate by the forcing of air through the slit which separates them. The accuracy and promptness with which the tension of the vocal chords and the width of the slit between them can be changed and adjusted, the perfect closure of the glottis at regular intervals, and the resonance of the roof of the mouth, all combine to make the human voice the most perfect of musical instruments.

The Phonograph is an instrument invented by Edison, an American, for reproducing sounds, especially those of the human voice. To form the "record," the sound waves are made to fall on a diaphragm to which is attached a stylus with a sharp cutting edge, in contact with a wax cylinder or disc, in which it cuts a groove as the latter revolves, the depth of this groove varying with the vibration of the diaphragm. To reproduce the sound, the stylus is replaced by one with a round end, and as the record revolves, it causes the stylus to vibrate in precisely the same manner as did the one which cut the grooves. These vibrations are communicated to the diaphragm, which is thus made to reproduce, exactly, its previous vibrations, and thus reproduce the original sound waves.

The Velocity of Light was first determined by Roemer, a Danish astronomer, as long ago as 1676. He was observing one of Jupiter's moons which in the course of its rotation round that planet disappeared and reappeared, thus acting as a lamp suddenly extinguished and relit. The period that elapsed between two successive lightings up of this celestial lamp could be exactly timed. His first observations were made at a time when the earth was nearest Jupiter, but as our world continued in its orbit this distance increased and Roemer found his little moon unpunctual, gradually getting later and later, and at the end of six months Jupiter's moon was fifteen minutes late in making its appearance.

By a flash of genius Roemer attributed this difference in time to the time taken by light to travel the increase in distance between the earth and the moon he was observing, and on this assumption he calculated that the velocity of light must be 192,000 miles a second. Modern instruments and methods other than those used by Roemer give the velocity of light as 186,000 miles a second.

As regards terrestial distances the velocity of light is therefore instantaneous, especially as compared with sound. When a gun is fired at some distance from an observer the flash and the smoke are seen first and the sound is heard some time later. Thunder is frequently heard some seconds after the lightning flash is seen, and knowing the velocity of sound in air, a fairly accurate estimate may be made of the distance of the centre of the storm area from the observer.

Composition of Sunlight.—If a beam of white light, *i.e.* sunlight, be passed through a glass prism, it will be found to emerge as a broad band of many colours, separate and distinct from each other, with each colour occupying a definite position in this band. The colours, in order, are red, orange, yellow, green, blue, indigo, and violet, with the red farthest from the thick end of the prism. White light is thus seen to be composite, and is exactly similar in character to a chord of seven notes. Just as the notes of the chord are produced by impulses differing in wave length, so are these colours. Thus about 39,000 waves of red light, placed end to end, would measure an inch in length, while the waves constituting the violet colour are still smaller, 58,000 of these being required to occupy the same length. The wave lengths of the colours intermediate between the red and violet vary between these extremes. When the enormous velocity of light is considered, the formula $v = nl$ gives the frequency n as 459,613,440,000,000 for red light. This inconceivable number of waves must enter the eye in a single second in order to produce the sensation "red," and a number one and a half times as great before we can see "blue."

It was Newton who first analysed sunlight with a prism, and he called the coloured image of the sun he obtained, a "spectrum." He gained still further proof of the composition of white light by passing the spectrum through another prism, placed in an inverted position as compared with the first, and thus causing the colours to reblend and recombine to form white light again.

This constitution of sunlight forms the means whereby the wonderful variety of colour, as seen in nature, is produced. If a strip of red paper is placed in the red end of the spectrum, it will appear a vivid red, its colour being intensified, but if placed in the blue end of the spectrum, it will appear jet black, which implies an entire absence of colour. Similarly blue will appear intensely blue at the blue end and black at the red end of the spectrum. Evidently, therefore, an object which looks red in sunlight, absorbs entirely the blue light, reflecting none of it back, but it reflects well the red light. Similarly with all bodies—they exercise a selective action, absorbing in various proportions certain of the constituents of any light and reflecting the remainder—a process which lends itself to

infinite variety. A familiar experience, is that of finding a piece of cloth look a different colour under gas light from what it does in the day time, and different again under electric light. The constituents of these lights (sun, gas and electric light) are not quite the same, but the selective action of the material remains constant, leaving a different remainder in each case to be reflected, and thus producing different colour effects.

The Spectroscope is an instrument by means of which an examination of the character of the light emitted by any source is carried out. It consists of two tubes mounted on a graduated circle, in the centre of which a prism is placed. One of these tubes, free to rotate round the circumference of the circle—a rotation which can be accurately measured—contains a number of lenses which convert it into an astronomical telescope. The other tube called the *collimator* faces the light which is admitted into it by means of a narrow slit; it also contains a lens, so placed as to cause the light to issue from it in a parallel beam. This beam passes through the prism, and is observed or examined by means of the telescope.

Spectrum Analysis.—When the spectrum of sunlight is examined by this instrument it is found to be traversed by a large number of dark lines, parallel to each other and to the slit of the spectroscope. These lines are called *Fraunhofer lines*, after their discoverer, and their meaning becomes clear from the following experiments. When the light given out by a glowing gas is similarly examined the spectrum consists of a number of *bright* lines. These lines vary in number and position with the substance of which the gas is composed, but they are definite both as to position and number for any particular gas. Further, the corresponding lines for each substance are also found in the sun's spectrum, occupying exactly the same positions, but with this difference, that in the sun's spectrum they appear as *black* lines instead of bright. Now if white light, such as that obtained from an electric arc, be passed through a glowing gas, these black lines are reproduced; cut off the white light, and the black lines become bright. The black lines are therefore due to the absorption by the gas of that portion of white light which corresponds in frequency to its own rate of vibration. The phenomenon is similar to that of resonance, in which a sounding body will cause another, at a distance from it, to sound and emit its note, provided that the latter's natural period of vibration corresponds with that of the sound waves impinging upon it.

Fraunhofer's lines are therefore "absorption" lines. As was first explained by Kirchhoff, the light from the white hot nucleus of the sun must first pass through glowing gases which surround that body. The elements in those gases absorb portions of the light which correspond in frequency to their own, and thus notify their presence 92,000,000 miles away, by leaving one or more dark lines on the spectrum examined in the laboratory. Careful examinations of all the known elements have fixed the positions in the spectrum of their respective absorption lines, and a comparison with the sun's spectrum reveals the remarkable fact that all these elements are also present in the gases surrounding the nucleus of our luminary. Some time ago certain lines in the sun's spectrum could not be identified with any known terrestrial element, and were said to be due to an unknown substance which was called "helium"; but later, this element, which proved to be a gas, was also discovered as a constituent of the air in such minute quantities that it had previously escaped detection. Here we have the case of an element being first discovered in the sun before it was known on the earth, such is the remarkable vision of the eye of science. Spectroscopic examination of the light from the stars shows that their constitution is the same as that of the sun.

The application of Doppler's principle described on p. 644, shows that the motion of a luminous body at a rapid rate must produce a shift of the spectrum absorption lines—towards the violet end of the spectrum when the body is moving towards us, since such motion results in an increased frequency which is equivalent to a diminution in wave length. Conversely, a motion away from us must move the lines towards the red end of the spectrum.

A measurement of the extent to which the lines are so moved provides the datum for a calculation of the velocity of the moving body, and in this way it has been found that the star Arcturus, for example, is approaching the earth with a velocity of 42 miles a second, while Aldebaran is travelling away from us at the rate of 45 miles a second.

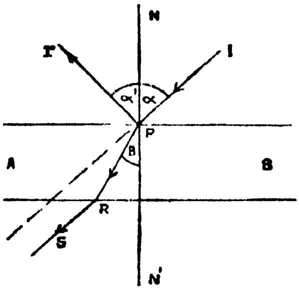
The eye aided by the spectroscope enables us to examine the visible portion of the sun's spectrum, but a combination of Langley's bolometer with the spectroscope reveals the fact that the spectrum extends a long way beyond the red end, and the use of chemical preparations, such as those with which camera plates are coated, proves that the spectrum also extends beyond the violet end. The visible spectrum thus forms but a small part of the total. Extending for many "octaves" beyond the red end are invisible rays of continuously increasing wave lengths and constituting heat rays; beyond these again, and of still greater wave length, are electrical waves which during a period of sunspot activity are found to affect the magnetic instruments in our observatories; beyond the violet end of the spectrum are also invisible rays decreasing in wave length and which are chemically active. These latter are called

"actinic" rays, and are the ones which affect photographic plates and the leaves of plants, in which they decompose the carbon dioxide absorbed from the atmosphere, the carbon being assimilated by the leaf and the oxygen given off. Red light, being sufficiently far removed from the actinic end of the spectrum, is therefore the light used by a photographer in his dark room; blue light would spoil his plates.

The sun's beneficent rays have provided this planet with all the energy it possesses and is daily adding more to the store, and the analysis of these rays which scientists have made with the aid of but a very few ingenious instruments shows that this energy is supplied in four forms—as electrical energy, heat energy, light energy, and chemical energy.

We must now turn to certain other properties of light which have very important applications.

Reflection and Refraction.—When a beam of light is incident upon a transparent body such as glass, a certain proportion of it will be reflected, a little will be absorbed, and the rest will pass through. This is represented in Fig. 11



AB representing a glass block with parallel faces, IP the path of an incident ray, PI′ that of the reflected ray, and PRS the path of the ray passing through the glass and onwards. NPN′ is a line through P, the point of incidence of the light, perpendicular to the surface, and called the *normal*. The angle IPN (or α) is called the *angle of incidence* and the angle I′PN (or α') the *angle of reflection*. The ray of light in passing through the glass is bent, or *refracted*, as it is called, out of its original path (represented by the dotted line) *towards* the normal: the angle RPN′ (or β) is therefore called the *angle of refraction*. On emerging from the glass slab into the air the ray is bent back again away from the normal and into a direction parallel to the original one, the final result thus being a shifting of the path of the ray by an amount depending on the thickness of the slab.

Substances like glass are said to be "optically denser" than air, and the effect of the passage of light from one medium into an optically denser one is to cause refraction *towards* the normal, while the passage in a contrary direction produces refraction *away* from the normal.

Reflection and refraction will now be considered in greater detail.

Reflection.—The laws governing reflection are only two in number. (1) The angle of incidence is equal to the angle of reflection. (2) The incident ray, the normal, and the reflected ray are all in the same plane.

The result of these laws, in the case of a plane surface such as a common mirror, is to produce an image which seems to be as far behind the mirror as the object is in front of it. This is clear from Fig. 12, in which MM represents the

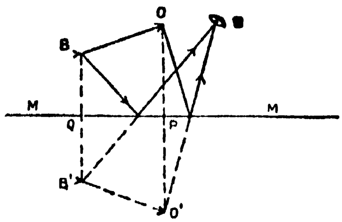


FIG. 12.

mirror, OB the object and E the eye of the observer. Since we judge the position of an object by the direction of the rays *as they enter the eye*, the result of the reflection of a ray proceeding from O is to "place" O at O′; similarly B is judged as being at B′ and so with all intervening points between O and B. It can be easily proved that OP = O′P and BQ = B′Q.

If a plane mirror is rotated, the angle through which the reflected light is turned is exactly twice as great as that through which the mirror itself has moved. This provides us with a means of detecting minutely small motions. Gauss (1777–1855) attached small mirrors to his suspended magnets, and by watching the beam of light reflected from them on to a scale placed at some distance, he was able to detect the slightest thrill on the part of the magnets. The infinitely small elongation produced in a bar of metal by the mere heating of the hand may be so magnified by this method as to be easily perceived.

The Sextant is an instrument also depending on this principle, and is used for determining the angle subtended at the eye of an observer by two distant objects. By means of it the altitude of the sun is found daily by the sailor at sea. It consists of a telescope, two mirrors, and a scale. One of the mirrors is fixed with its centre directly in front of the telescope; only the lower half of this mirror is silvered, the upper half being left clear. Above this is a fully silvered mirror arranged parallel to the first. The telescope is brought to bear on an object situated on the horizon, which is viewed through the clear half of the first mirror. The second

mirror is then rotated until it reflects an image of the sun on to the lower half of the first mirror, where this image is again reflected into the telescope and seen alongside of the first image. The angle through which the second mirror is rotated is read off on a scale and is equal to half the angle between the two objects; doubling this angle therefore gives the required altitude.

The application of the laws of reflection to spherical mirrors requires more extensive treatment, for which the reader is referred to any text-book on Light.

Reflection of sound is precisely similar to that of light and is governed by the same laws. Familiar instances are found in echoes, in the Whispering Gallery of St. Paul's, and in sounding boards, which function as mirrors, and are fixed in halls so as to reflect sounds into the auditorium.

Refraction.—The principle which governs the refraction of light was first discovered by Willebrod Snell about 300 years ago, and may be stated as follows: *The ratio of the sines of the angles of incidence and refraction is constant for any particular substance, though it varies from one substance to another.* Or using the notation of Fig. 11, $\frac{\sin \alpha}{\sin \beta}$ = a constant.[1]

This constant ratio is called the *index of refraction* for that substance. In the case of the passage of light from air to water it is equal to $\frac{4}{3}$. If the path is reversed, the index of refraction becomes $\frac{3}{4}$, so that if ${}_{A}\mu_{B}$ represents the refractive index on the passage of light from substance A to substance B, the refractive index ${}_{B}\mu_{A}$ from substance B to A is equal to $\frac{1}{{}_{A}\mu_{B}}$.

Since the refractive index of any substance is a measure of the amount by which light is bent out of its path in passing from air into that substance, its value plays a very important part in the manufacture of glasses for optical instruments in which the refraction of light is utilised for specific ends. Further, the refractive index depends not only on the substance through which the light passes but also on the colour of the light itself. The shorter the wave length of the light the greater is the amount of bending it undergoes. This is evident from the following table of refractive indices for different substances and for rays differing in wave length, the direction of the rays being from air to the substance.

Substance.	Refractive Index.		
	Red.	Orange-Yellow.	Blue.
Water	1·330	1·334	1·338
Crown glass . .	1·528	1·534	1·540
Flint glass . .	1·578	1·587	1·597
Rock salt . . .	1·537	1·544	1·553

This table explains why light composite in character spreads out into a spectrum on passing through a thick prism. It is also evident that the thicker the prism the greater will be the extent to which the various colours will be finally separated and the longer will be the resulting spectrum.

The Rainbow is an example of the resultant effects of both reflection and refraction. It is formed by the rays of the sun falling on raindrops situated in certain positions with respect to the eye of the observer. The rays are refracted in the drop at some point such as A and the component colours are dispersed; reflection then takes place at a point B on the back surface, and another refraction at C accompanied by still greater dispersion. Those rays which have undergone minimum deviation by the two refractions and one reflection will have maximum intensity, and from the known refractive index of water,

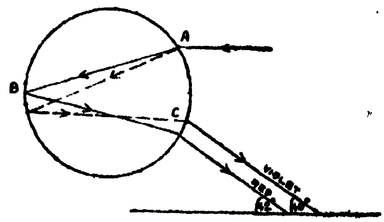
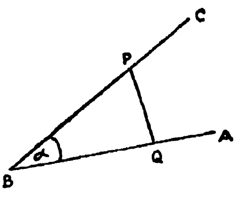


FIG. 14.

[1] *Note on the Sine, Cosine, and Tangent of an Angle.*—If ABC represents any angle α and if any perpendicular PQ be drawn from either of the lines forming the angle on to the other, so as to form a right-angled triangle PBQ, then the sine of the angle α (written sin α) is the ratio of this



perpendicular PQ to the hypotenuse BP of the triangle so formed. This remains constant for any given angle from whichever point P may be drawn. The sine of an angle cannot be greater than unity.

The cosine of the angle α (written cos α) is the ratio $\frac{BQ}{BP}$. This also cannot have a value greater than unity.

The tangent of the angle α (written tan α) is the ratio $\frac{PQ}{BQ}$, and since this is equal to $\frac{PQ}{BP}/\frac{BQ}{BP}$, $\tan \alpha = \frac{\sin \alpha}{\cos \alpha}$. The tangent of an angle may have any value from zero to infinity.

All three (sine, cosine, and tangent) may have negative values.

Values of the sine, cosine, or tangent of any angle will be found in any book of mathematical tables. Those for angles from 0° to 90° are given at the end, p. 670.

calculation shows that such rays will issue from the drop at an angle of about 41° with the direction of the sun's rays. Hence looking in that direction the drops will appear as bright points of light, and owing to the dispersion which takes place the violet colour will appear as a curve, all points on which make an angle of 40° between the eye of the observer and the direction of the sun's rays, while the red will be on a curve subtending an angle of 42°; colours of intermediate wave-lengths will appear between these two, and thus we get a series of circular arcs showing the spectrum colours with the red on the outer and the violet on the inner edge.

A secondary and fainter bow is sometimes outside the primary bow just described,

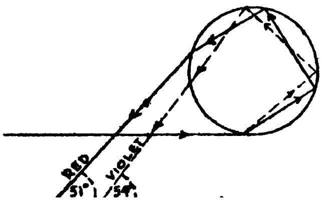


FIG. 15.

and is caused by light which has been reflected *twice* in the raindrop, the angles of minimum deviation being in this case 54° for the violet and 51° for the red rays. In this bow, therefore, the violet arc is seen to be on the outer edge.

Lenses made of glass are the chief means whereby light is controlled so as to produce certain required results. Of these the commonest are the *convex* and *concave* forms (Fig. 16), the former being thickest and the latter thinnest at the centre.

If a parallel beam of light bounded by the lines AB and CD fall on such a lens, the rays will issue in such a manner as to converge to-

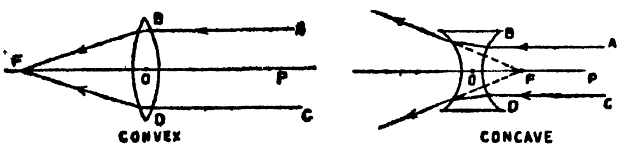


FIG. 16.

wards a single point F in the case of a convex lens, or as it is frequently called *convergent* lens, and to diverge as *if* from a single point F in the case of a concave or divergent lens. The point F is called the *focus* of the lens and the distance OF the *focal length.* If a source of light be placed at F, so that rays radiating from it are incident on the lens, the emerging beam will be parallel.

If r_1 is the radius of curvature of the first surface of a lens on which light is incident, r_2 that of the second, f the focal length, and μ the refractive index, then f depends on the values of μ, r_1 and r_2. The relation between these quantities is given by the equation $\frac{1}{f}=(\mu-1)\left(\frac{1}{r_1}-\frac{1}{r_2}\right)$. This formula is, however, based on the convention that distances measured *from* the lens in a direction opposite to that of the incident light are reckoned as positive, while those measured in the *same* direction as that of the incident light are reckoned as negative. This convention must be borne in mind whenever the reader is dealing with lenses. For both kinds of lenses $(\mu-1)$ is a positive quantity, the value of μ for glass being greater than 1, but r_1 is negative in the convex lens and positive in the concave, while the reverse is the case for r_2. Consequently $\frac{1}{f}$, and therefore the focal length of a convex lens is negative while that of a concave lens is positive. In other words, the focus F is, in the case of a convex lens, on the side remote from the incident light, and in the case of a concave lens, on the same side as that of the incident light, as is shown in the figure. The radius of curvature of a lens is easily measured by means of a spherometer, a little instrument constantly used by opticians. Assuming 1·5 as an approximate value of μ for glass, we will as an illustration of the use of the above formula find the focal length of a convex lens whose first surface or surface incident to the light has been found to have a radius of curvature of 8 cms. and the second surface one of 6 cms. We have

$$\begin{aligned}\frac{1}{f}&=(1{\cdot}5-1)\left(-\tfrac{1}{8}-\tfrac{1}{6}\right)\\&={\cdot}5\times(-{\cdot}292)\\&=-{\cdot}146\text{ cms.}\\\therefore f&=-6{\cdot}85\text{ cms.}\end{aligned}$$

The value $\frac{1}{f}$ is called the *dioptric strength* or the *power* of the lens, and opticians use as the unit of power, that of a lens having a focal length of 1 metre. This unit is called a *dioptre.* The power of the lens just calculated would therefore be 14·6 dioptres. The more strongly curved the surfaces of a lens are, the greater is its "power." There is also a convention to call a convergent or convex lens a *positive* lens and a divergent or concave lens a *negative* one—which is rather unfortunate and confusing, as the focal length of the former is negative and that of the latter positive.

The position, size, and form (whether erect or inverted) of an image formed by a lens may be obtained from a geometrical construction or from the equation $\frac{1}{f}=\frac{1}{v}-\frac{1}{u}$ in which u represents the distance of the object, and v that of the image from the lens, due regard being paid to the convention as to signs. To find the posi-

tion of the image this may be written $\frac{1}{v}=\frac{1}{f}+\frac{1}{u}$. Since u must always be positive we have (a) for a convex lens $\frac{1}{v}=-\frac{1}{f}+\frac{1}{u}$, and therefore v is negative as long as u is greater than f, and positive when u is less than f. Hence the image is on the side of the lens farthest from the object, as long as the latter is situated at a distance from the lens greater than its focal length (the image being then said to be a *real* one), and the image is on the same side of the lens as the object when the latter is at any distance from the lens less than the focal length of the lens (the image being then said to be *virtual*); (b) for a concave lens $\frac{1}{v}=\frac{1}{f}+\frac{1}{u}$ and v is therefore *always* positive or the image is *always* situated on the same side of the lens as the object (the image being virtual).

The Magnification produced by a lens is given by the ratio $\frac{v}{u}$. Applying the formula $\frac{1}{f}=\frac{1}{v}-\frac{1}{u}$ we see that the magnification $=1-\frac{v}{f}$ or $1-\frac{u}{u+f}$.[1] The second of these expressions indicates that for a concave lens the magnification must be less than 1, that is the image is smaller than the object, while the first shows that as long as f is negative and v positive the magnification is greater than 1.

The condition for magnification is therefore a convex lens of short focal length, and the shorter the focal length the greater the magnification. This is exemplified in the ordinary magnifying or reading glass or in a simple microscope, which consists of a single short-focus convex lens.

Thick Lenses.—The preceding formulæ and remarks apply only to *thin* lenses. In the case of lenses of any appreciable thickness such as are used in all good optical instruments, the conditions involved are much more complicated, and the mathematics necessary for a study of them is of an advanced character and quite outside the scope of this article. I will therefore content myself with a brief outline of the two chief problems encountered. (a) A thick lens produces distortion of the image, or, as it is technically termed, *spherical aberration.* This may be overcome either by the use of a diaphragm or "stop" to diminish the "aperture" of the lens, so that only the light which passes through the central portion of the lens is used,

(a) $\frac{1}{f}=\frac{1}{v}-\frac{1}{u}$

$\therefore \frac{v}{f}=1-\frac{v}{u}$

$\therefore \frac{v}{u}=1-\frac{v}{f}$

(b) $\frac{1}{f}=\frac{1}{v}-\frac{1}{u}$

$\therefore \frac{u}{f}=\frac{u}{v}-1$

$\therefore \frac{u+f}{f}=\frac{u}{v}$

$\therefore \frac{v}{u}=\frac{f}{u+f}=\frac{f+u-u}{u+f}=1-\frac{u}{u+f}$

or by the use of a lens only one surface of which is curved, the other being plane. Such a lens is called *plano-convex* or *plano-concave* according to the form of curvature of the curved surface, and is of frequent use in optical instruments, as the "stop" method has many disadvantages, not the least of which is that it cuts off a good deal of light. In using this form of lens the curved surface should face *towards those rays* (incident or emergent) *which are the more nearly parallel to the axis of the lens.*[1] If reversed the spherical aberration becomes about four times as great. Consequently, in the case of a microscope where the object is placed very close to the lens, the plane side faces outwards, while in a telescope or field glass the curved side faces outwards.

(b) A thick lens acts somewhat like a prism and produces marginal colour effects in the image—this is termed *chromatic aberration.* To obviate it, a convergent lens of crown glass is cemented together with a divergent lens of flint glass (Fig. 17). The former is more strongly convergent for blue than for red rays, while the latter is more strongly divergent for the blue rays; the result is that the colour spectrum is folded back on itself, as it were, the red and blue colours being brought into coincidence. Such a combination of lenses is called an *achromatic* combination; in it the free surface of the flint glass is left plano, while the curved surface of the crown glass is made to face the incident light so as to minimise the effects of spherical aberration.

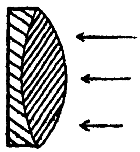


FIG. 17.

In good optical instruments, therefore, we never have single lenses, but combinations to reduce both spherical and chromatic aberration. In the following descriptions of a few such instruments this must be taken for granted; by a convergent or divergent lens will be meant a combination of lenses which produces the same resultant effect.

Optical Instruments—The Eye, a diagrammatic section of which is shown in Fig. 18, is the chief and most wonderful optical instrument of all. An opaque membrane S, called the *sclerotic*, encloses a nearly spherical chamber. This membrane becomes transparent in front, at C, where it is called the *cornea* and forms, as it were, a window for the admission of light. Lining the sclerotic is a black pigmented coating Ch, called the *choroid*, which merges into the *iris* I, opaque and generally coloured, and containing a circular opening near its centre termed the *pupil*. The pupil is capable of contracting or expanding, according to the intensity of the light, and thus acts as a blind or screen controlling the quantity of light which enters

[1] The axis of a lens is a line passing through its centre and perpendicular to the surface—the line OP in figure 16.

the eye chamber. The choroid probably acts in a manner similar to the black paint with which the insides of cameras and telescope tubes are covered; it prevents a general illumination of the interior.

Between the iris and the cornea is a small chamber A containing a liquid called the *aqueous humour.* Immediately behind the iris is the *crystalline lens,* attached to the sclerotic by

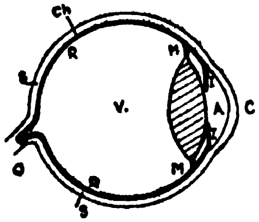


FIG. 18.

muscles MM, called the *ciliary* muscles, the contraction and relaxation of which causes the lens to become thinner or thicker, in other words, to vary the radii of curvature of the lens and so alter its focal length. The eye is therefore said to possess the *power of accommodation.* The lens itself is not simple in structure; the surface nearest the cornea is less curved, so that it approximates to a plano-convex form; also, it is not homogeneous, but increases in density from its outer to its central portion. This, together with its plano-convex form, tends to diminish spherical aberration. Covering the choroid is a semi-transparent network of nerve fibres and blood vessels, called the *retina,* RR. All these nerve fibres terminate on the *optic* nerve O, which runs into the brain. Between the lens and the retina, the chamber V is filled with a gelatinous liquid called the *vitreous humour.* Besides functioning as refracting substances, and probably also to absorb heat rays, both humours (aqueous and vitreous) act as cushions helping to protect the eye from a blow. Any damage to the vitreous humour is irreparable, but the eye itself will replace the aqueous humour within about eight hours.

The whole forms an optical system producing a real, inverted image of an object, so as to fall on the retina, which, under the action of light, gives in some unknown and marvellous manner the sensation and consciousness of "sight." As a result of experience and co-ordination with the sense of touch, the mind re-translates the inverted image into an upright one.

The instrument, as we see, is complete in every detail, containing, as it does, an adjustable "stop" or diaphragm in the pupil, a compound lens of variable focal length, adjustable at will in a fraction of a second, black pigmented sides, and lastly the retina—a most efficient, sensitive, self-recording "plate," which responds immediately, requires no "development," and is always ready for the next "picture."

Defects of Vision.—Those which are of common occurrence are (*a*) *Myopia* or short-sight, (*b*) *Hypermetropia* or long-sight, and (*c*) *Astigmatism.*

(*a*) In the perfect eye all points from a distant object focus on the retina. In the case of myopia such points are, owing to the excessive length of the eye, focussed a little *in front* of the retina even when the crystalline lens is at its flattest; this produces a blurred image. Such an eye can, however, see near objects distinctly, although its *near point* (*i.e.* the minimum distance of distinct vision) is much closer than it is in the normal eye. To correct for myopia, since the crystalline lens is evidently too convergent, a concave spectacle lens is placed in front of the eye so as to reduce this convergence. If d is the near point of the eye, the focal length of the lens should also be d, as then it will focus parallel rays from distant objects to a distance d from the eye.

(*b*) In the hypermetropic eye light from a distant object is, owing to the deficient length of the eye, focussed *behind* the retina. The accommodative power of the crystalline lens is, as a rule, sufficient to rectify this for distant objects, but not for objects fairly close to the eye such as printed matter. The crystalline lens is in such a case evidently not sufficiently convergent even when the ciliary muscles are fully relaxed, and the spectacle lens required is therefore a convex one so as to form, together with the lens of the eye, a more convergent system than the latter alone does.

(*c*) Astigmatism is due to non-symmetrical curvature of the cornea, which may be more curved in the vertical plane than in the horizontal, or *vice versa*; the result is distinct vision in one plane and indistinct in another. Such an eye may, for example, see clearly vertical lines and but dimly horizontal lines or the reverse. The remedy for this is a cylindrical spectacle lens so as to re-inforce the eye in the plane of least curvature of the cornea. Astigmatism may be combined with either of the two defects previously dealt with, in which case the spectacle lens is of a double character, the surface nearer the eye being spherical (concave or convex as the case may require), while the outer surface is cylindrical.

The Astronomical Telescopes in use are of two kinds (1) refracting, and (2) reflecting. The former contains a convergent lens or system, termed the *object glass* or *objective,* which is turned towards the object to be viewed, and a convergent lens termed the *eye-lens* or *eye-piece,* to which the eye is applied. This system produces a magnified inverted image—inversion being of no consequence when viewing stars. If F is the focal length of the objective and f

that of the eye-piece, the magnification of such an instrument is equal to $-\frac{F}{f}$, the minus sign implying inversion of the image. Consequently such a telescope must contain a long focus objective and a short focus eye-piece. This accounts for the enormously long telescopes in use in observatories. The one used at the Yerkes Observatory, Chicago, is 75 feet in length and possesses an object glass 40 inches in diameter, a large aperture for the objective being required in order to collect as much light as possible. Naturally there are great difficulties connected with the construction of such large objectives—that of the Lick Observatory, for example, cost £10,000.

In the reflecting telescope no objective is required, the light falling directly on a parabolic mirror, from which it is reflected into an eye-piece. The advantages of this form of telescope are that a wider aperture can be used, there is no spherical or chromatic aberration, and as no objective is required it is very much cheaper. On the other hand, however, the image is not so bright as in the refracting telescope, a certain percentage of light being lost in the reflection.

Galileo's Telescope.—Galileo was the first to invent and point a telescope at the skies. His instrument contained a convergent objective and a divergent eye-piece. The telescope being much shorter than an astronomical telescope of equal magnifying power, and the image being upright, has led to the adoption of this optical arrangement for use in opera glasses.

The Terrestrial Telescope produces an upright image by means of a convergent lens placed between the objective and the eye-piece; otherwise the optical system is similar to that of the astronomical telescope.

The Microscope contains a short focus objective and a short focus eye-lens, the object being placed very close to the object glass. Both objective and eye-lens are convergent systems, and in a very high-power instrument the former is very complicated in structure.

The Magic Lantern is an instrument for throwing on a screen an enlarged image of a photograph in the form of a slide. The focussing lens consists of two compound lenses separated an appreciable distance from each other. This forms an enlarged inverted image corrected for both spherical and chromatic aberration. The source of light is obtained by burning a mixture of coal-gas and oxygen in front of a lime which is thereby made to glow very brightly, or by using an electric carbon arc. Between this light and the focussing lens there is a *condenser* consisting of two plano-convex lenses with their curved sides in contact; its function is to collect the rays so as to project them all into the focussing lens. The slide is placed in an inverted position between the condenser and focussing lens and immediately in front of the former.

MAGNETISM AND ELECTRICITY

As neither magnetism nor electricity can be directly apprehended by our senses in the same manner as sound, light, or heat, it would seem desirable at the outset to state what magnetism or electricity is. This, however, cannot be done, because nobody knows. We know how to produce both; we know their properties and the laws to which they conform; we know how to deal with them, how to control them and how to use them; we know that the two are intimately connected with each other—electricity in motion produces magnetism as an accompanying phenomenon, while magnetism in motion produces electricity, but what they are is part of the Great Mystery. Recent researches and newly acquired knowledge seem to indicate that electricity is the basis of the universe, while matter is but the form or manner in which our senses interpret it. (See Electron Theory, p. 668.)

Magnetism.—There is a certain oxide of iron—a hard black stone—which was known to the ancients as possessing the magic property of attracting to itself small pieces of iron and steel, and which was found by them in magnesia (in Asia Minor); hence the name "magnet." This stone, now known as *magnetite*, is however found in many localities, and was known to the Chinese as long ago as 2400 B.C. They also knew that it possessed the power, when suspended so as to have complete freedom of movement, of always coming to rest in a definite position—one end pointing north and the other south. There is no record of any such knowledge among Europeans until the eleventh century, from which time onwards the stone began to be used for navigation purposes, and received the name of *lodestone* or "leading-stone."

A magnet is a substance which possesses the two-fold property of (*a*) attracting small pieces of iron or steel, and (*b*) assuming a position of rest such that its axis lies in a direction which coincides very closely with a geographic meridian. This property, or "magnetism" as it is called, can be easily imparted to some substances such as iron, steel, nickel, cobalt, chromium, cerium, and manganese. These substances are also attracted by a magnet, and are called *paramagnetic* or magnetic substances. Of these iron and steel have the greatest magnetic power, and only nickel and cobalt are at all comparable with them in that respect. There are a few substances, such as antimony, aluminium, bismuth, and copper, which are even repelled by a magnet and are consequently termed *diamagnetic*. The majority of substances are magnetically neutral—neither attracted nor repelled by a magnet.

The two chief methods of magnetising a piece of iron or steel are (*a*) rubbing with one or two

magnets for some time—the rubbing must be performed always in the same direction—and (b) winding a copper wire, covered with silk or gutta-percha, round the piece of iron or steel and passing an electric current through the wire. It is found that iron loses its magnetism quickly, and if the iron is "soft," very quickly, but steel retains its magnetism for a long time. Steel forms a "permanent" magnet—with a modified meaning of the word permanent—and magnets are therefore usually of steel, but as we shall see later, soft iron magnets are also put to important uses in many ways.

With a couple of steel magnets let us perform a few simple experiments. If either is dipped into a heap of iron filings it will be found that great clusters of the filings have been attracted at the *ends*, or *poles*, as those are called, while hardly any have attached themselves to the middle or "equatorial" portion of the magnet. It seems, therefore, as if the magnetism, whatever that may be, is concentrated at the ends. If now we break the magnet (which may consist of a magnetised knitting needle) into halves and test each half with the iron filings, we shall find that each half behaves in exactly the same way as the whole did previously. This subdivision may be continued with precisely the same result each time. It seems, therefore, that the whole magnet consists of a number of little magnets arranged end to end lengthwise.

Suspend one of the magnets by a fine thread, or balance it on a point so that it is free to turn about a vertical axis through its centre of gravity, and it will come to rest with one end pointing north and the other south. Mark one end so as to distinguish it from the other and displace it from its position, and you will find that on coming to rest again the *same* end or pole will again point in the same direction. The pole which points north is called the *north-seeking pole*, and the one pointing south the *south-seeking pole*. Having in this way found the north and south-seeking poles respectively of the two magnets, suspend one and bring the other slowly up to it, and it will be found that when the south-seeking pole of one is presented to the north-seeking pole of the other they attract each other, but if the north-seeking pole of the one is presented to the north-seeking pole of the other, they repel each other. There must, therefore, be some difference in the magnetism of the two poles of a magnet—a difference summed up in the rule that "like poles repel, while unlike poles attract each other."

It must be remembered that in practice we cannot get these two kinds of magnetism separated. Whenever one end of a body exhibits north-seeking polarity, the other end will invariably exhibit south-seeking polarity.

Theories about Magnetism.—The earlier philosophers assumed that magnetism was due to a fluid which entered the substance on its being magnetised. The theory was similar to the caloric fluid theory then in vogue to explain the phenomenon of heat. The modern view is that each molecule of a body is a little magnet, but these little magnets are normally arranged in a haphazard fashion with their respective poles pointing in various directions. They thus neutralise each other and no magnetic properties are exhibited, but in the case of bodies which are easily magnetised the rubbing of a magnet over them "sets" or turns these molecular magnets so that all like poles point in the same direction.

The Earth a Magnet.—If a light magnetic needle be balanced so as to be free to revolve in a vertical plane, it will not come to rest in a horizontal position, as it would do if it were not magnetised, but in a position making an angle of about 67° with the horizontal, and with its north-seeking pole dipping down. This "dip" varies at different parts of the earth's surface; in London it is about 67°, but it increases as we travel northwards and decreases as we proceed in a southerly direction. South of the equator the dip becomes reversed, the south-seeking pole now dipping below the horizontal, the magnitude of the dip again increasing with distance from the equator.

The behaviour of such a "dip-needle" as well as that of a compass needle, which is merely a strip of magnetised steel, and which always points in a northerly and southerly direction, can only be explained on the assumption that the earth itself is a large magnet whose attraction is the cause of the phenomena observed with magnetised bodies—an assumption conclusively proved by innumerable experiments and observations. The magnetic poles of the earth do *not*, however, coincide with the geographic poles.

The non-coincidence of the magnetic with the geographic poles accounts for the divergence of a compass needle from the true north and south. The amount of this divergence, measured in angles, is called the magnetic *declination*, a knowledge of the exact value of which is necessary to enable mariners to make corrections for purposes of navigation.

The declination, the intensity of the earth's magnetism in a horizontal direction, and the "dip" are called the *Magnetic Elements*; the values of all three must be known before the extent of the earth's magnetism at any place can be exactly specified. From records of these elements, made and kept at various observatories scattered over the globe, magnetic maps are constructed on which the required data are marked. The magnetic observations made during Sir E. Shackleton's last Antarctic expedition showed that the variation lines on the charts used by all ships travelling south of the equator were a little bit out. These have now been altered and the saving thereby effected, of

one or two hours to every ship on each voyage, amounted in a few years to much more than the cost of the expedition.

Law of Inverse Squares.—Careful experiments prove that the law of attraction (or repulsion) between the poles of two magnets is exactly similar to the law of gravitation, viz., the force of attraction (or repulsion) varies directly as the product of the magnetic strengths of the two poles and inversely as the square of the distance separating them. Mathematically, this is expressed by the equation $F = k\frac{mm'}{d^2}$ where F represents the force, m and m' the respective pole strengths, d the distance between them, and k a constant depending on the medium separating the poles. If we make each of the quantities in this expression equal to unity we get a definition of unit pole strength when the medium is air, this definition being that "unit magnetic pole strength is such that when placed at unit distance (1 cm.) from a similar pole of equal strength it repels it with unit force (1 dyne.)"

We must next consider a couple of expressions which give the value of the force acting on a magnet that has been deflected out of the magnetic meridian through a measurable angle. This is important, as the easiest means of measuring the strength of an electric current is by reading the angle through which a magnetic needle is deflected by such a current.

Deflection of a Magnet.—Let PQ (Fig. 19) represent a magnet, originally at rest in the magnetic meridian NS, and which has been deflected by an angle α from its position of equilibrium. The problem is to find in terms of known quantities the value of the force tending to restore the needle to its original position. Let m be the pole strength of the magnet, l its length, and H the value of the force exerted by the earth's magnetism in the direction of the meridian, or the earth's "horizontal intensity" as it is called. The value of H varies at different points of the earth's surface, but is easily found by experiment; in London it is equal to ·18, which means that unit pole strength is acted on by a force of ·18 dynes in the direction of the magnetic meridian.

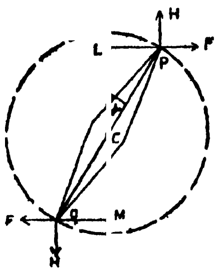


FIG. 19.

From P and Q draw PL and QM, each perpendicular to NS; then PL = QM. Now the pole P is acted on by a force mH in the direction PH; similarly the pole Q experiences a force mH in the direction QH. These two equal and parallel forces constitute a "couple" tending to turn the magnet back into the direction NS. The turning moment of this couple is equal to one of the forces multiplied by the distance between the lines of action of the forces, *i.e.* $m\mathrm{H} \times 2\mathrm{PL}$.

$$\text{Now PL} = \text{PC} \sin \alpha, \text{ or } \frac{l}{2} \sin \alpha.$$

$$\therefore \text{ the turning moment} = m\mathrm{H} \times 2.\frac{l}{2}\sin \alpha.$$
$$= m\mathrm{H}l \sin \alpha.$$

The pole of strength m of a magnet multiplied by its length l is termed the *magnetic moment of the magnet.* If we call this M, then the turning moment = MH sin α . . . (*Equation* 1).

Now let us suppose that by some means, such as an electric current, we produce a magnetic force F which acts in a direction at right angles to that of the earth's field—in the direction PF and QF—and that it is this force which has deflected the needle. The final position of the needle, at an angle α with the magnetic meridian, is of course such that the turning moment due to the force F is just balanced by that due to the earth's magnetism, which has just been found to be equal to MH sin α. The turning moment due to the magnetic force F is m.F × LM.

$$\text{Now LM} = 2\text{LC and LC} = \text{PC} \cos \alpha \text{ or } \frac{l}{2}\cos \alpha.$$

$\therefore$ the turning moment due to the force F, or

$$\mathrm{MH} \sin \alpha = m.\mathrm{F}.2.\frac{l}{2} \cos \alpha.$$
$$= m.\mathrm{F}.l \cos \alpha.$$
$$\therefore \quad \mathrm{MH} \sin \alpha = \mathrm{M.F} \cos \alpha.$$
$$\mathrm{F} = \mathrm{H} \cdot \tan \alpha \quad . \; . \; . \; (\textit{Equation } 2).$$

Hence, knowing H, a mere reading of the angle α by which the magnet has been deflected at once enables us to calculate the value of the magnetic force F which has produced the deflection.

Magnetic Field.—Place a bar magnet flat on the table, cover it with a thin piece of cardboard,


FIG. 20.

and sprinkle over the cardboard some iron filings. Tap the cardboard gently and the filings will arrange themselves in a pretty pattern of curves

as shown in the accompanying figure. These curves indicate the directions of the magnetic forces. Each curve is called a *line of force*. A single north-seeking pole (if we could have such a thing), placed on one of these lines would be driven along it towards the south-seeking pole of the magnet. The sum total of these lines of force is termed the *magnetic field* of the magnet. It is assumed for purposes of mathematical argument that these lines run, in the air, from the north to the south pole of the magnet, and through the magnet in the reverse direction, thus completing a circuit. The lines, as is evident from the figure, must crowd together in their passage through the magnet itself, while in the air they separate out more. There is a *tension* along each line, and as the lines spread out and away from each other we must further assume that each exerts a repelling force, in a direction at right angles to its length, on the neighbouring lines. The tension along the lines of force accounts for the attraction between unlike poles.

Magnetic Induction.—If a piece of iron be placed in a magnetic field some of the lines of force will of course traverse it, and as the iron is easily magnetisable, the tensions existing along the lines of force will turn the molecular magnets of the iron so that all point in the same direction, and thus cause the iron to become magnetised. This process is called "magnetisation by induction," the magnetic field having "induced" magnetism in the iron. The intensity of the magnetism induced will naturally depend on the strength of the inducing field. On removal of the inducing field the molecular magnets gradually turn back to their original positions, and the iron then loses the magnetism induced in it.

This brief outline of magnetism will enable the reader to understand the more important phenomena connected with electricity which must now engage our attention.

Electricity.—There are three chief methods of producing electricity—(1) by friction, (2) by chemical means, (3) by the movement of a wire in the neighbourhood of a magnet, or the *electro-magnetic* method as it is called. We will consider these in turn.

(1) **Frictional Electricity.**—This is the earliest known method of producing electricity, and is no longer in use except in the lecture room for demonstration purposes. Its interest is chiefly historical, but a study of the phenomena observed in connection therewith is useful.

As long ago as 600 B.C., it was known to the Greeks that if you rub a piece of amber, or *ηλεκτρον* (electron) as they called it, with a piece of silk it acquires the curious property of attracting light bodies, such as chaff, dust, thin pieces of paper, &c. It was not until the year A.D. 1600 that Dr. Gilbert of Colchester discovered that many other substances besides amber, such as diamond, glass, sulphur, sealing-wax, resin, &c., became possessed of the same property of attraction when vigorously rubbed. Gilbert called these substances *electrics*, and since his time the name *electricity* has been given to the power or agency which produces the attraction observed in connection with electrics.

Experiments show that not only is a charge of electricity produced on the electric itself, but also on the material with which it has been rubbed, and that the electricity produced on the one appears different in kind to that produced on the other. To distinguish between the two one is called *positive* electricity and the other *negative*. Electricity is thus similar to magnetism; not only are there two kinds of electricity, but it is impossible to produce a charge of one kind without at the same time producing an exactly equal quantity of the other; further, two bodies charged with similar kinds of electricity repel each other, whereas if one is charged with positive and the other with negative electricity they attract each other, the law of attraction or repulsion being exactly the same as for magnetic charges. The similarity, however, disappears in one important respect—an electrically charged body will give up some of its electricity to any body with which it comes into contact, and will part with its whole charge to the earth when given the opportunity.

Conductors and Non-conductors.—When a glass rod is rubbed with silk it is found that only the actual portion rubbed is electrified; the rest of the rod showing no signs of electrification. If a metal rod be similarly rubbed the *whole* of the rod will be electrified provided certain precautions are taken, such as wearing india-rubber gloves or mounting the metal rod on a glass support. In the case of the glass rod the electricity is apparently unable to spread, but is confined to the spot where it is produced. A substance like glass is therefore termed a *non-conductor* or *insulator*, since it will not conduct the electric charge from point to point. In the case of a metal rod, however, the electricity instantly spreads all over the rod, and, if held in the hand, would disappear through the body of the holder into the ground as fast as produced. Substances that behave thus towards electricity are called "conductors." The electrics of Dr. Gilbert were really non-conductors, the electric charges on them becoming manifest only because they were not conducted away into the ground sufficiently rapidly. If precautions are taken against conduction, however, *all* bodies will be found to be electrics and will exhibit electrification on rubbing.

Metals and solutions of salts in water form the best conductors, while the poorest conductors or the best non-conductors are ebonite, glass, shellac, sulphur, paraffin, gutta-percha, sealing-

wax, and silk. The latter are therefore used as "insulators" to prevent the escape of an electric charge; thus a copper ball, if mounted on a glass stand, will retain any charge imparted to it; wires in which a current is flowing are insulated by being covered with gutta-purcha or silk.

The Electrostatic Field.—The electricity produced in a body by friction is stationary and must not be confused with the electric current with which everybody is familiar. From a body thus charged with positive electricity lines of force stretch out in all directions through the surrounding medium, and where they terminate on other bodies these become negatively charged by induction. These lines of force are exactly similar to the magnetic lines of force surrounding a magnet, and indicate the directions along which a positive charge of electricity placed at any point in the neighbourhood would be repelled away from the electrically charged body, and, conversely, a negative charge attracted towards it; also, there is a tension along the lines of force in the direction of their length and a repulsion between them in a direction at right angles to their length.

If now we have two plates A and B (Fig. 21), one of which is charged positively and the other negatively, an electrical "field" will be established in the medium (air we will suppose) separating them, and on account of the tensions and repulsions along and between the lines of force of this field the medium will be put in a state of strain. If the plates are now joined by a copper wire W or any other good conductor, the lines nearest W will contract along it and vanish; the others will move up along the plates, and then in their turn contract and vanish along W. In this way the two plates will be discharged, a *current* of electricity travelling through the wire during this process, which finally results in a neutralisation of one kind of electricity by the other.

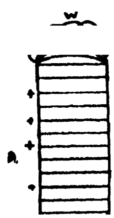


FIG. 21.

Potential.—We will now consider the production of this current from another point of view. Let us charge the plate A, supposed insulated and removed from the neighbourhood of all other conductors, by bringing small but equal charges of electricity up to it, one by one, from some source. After the plate has been charged with the first, then on bringing the second charge up a force of repulsion will exist between the two, increasing the nearer the second charge is brought to the plate. In order, therefore, to impart this second quantity of electricity to the plate, work or energy must be expended in overcoming this force of repulsion. Similarly with the third, fourth, and other charges, as they are brought up to the plate in turn, energy must be expended in the process of bringing these quantities of electricity to the plate, the energy thus expended increasing with each later charge that is brought up. What becomes of this energy? It is stored in the medium surrounding the plate in the form of a strain. Given an opportunity this potential energy will be released. A plate or any other body electrically charged, is said to possess or to have been "raised to a certain *potential*"; in other words it (or rather the medium surrounding it) has become endowed with a certain quantity of potential energy. The potential of such a charged body depends both on the quantity of electricity with which it has been charged and on its *capacity* for an electrical charge, which in turn depends on its shape. Potential is thus analogous to height of water in a vessel, which depends not merely on the quantity of water poured into it, but also on its capacity, which is of course limited. Or, potential might be compared to temperature, depending not only on the actual quantity of heat supplied to the body, but also on the latter's capacity for heat.

The potential at any point in the neighbourhood of a charged body is defined as the work, in ergs, that must be performed in bringing unit positive charge of electricity from infinity up to that point. If the body is charged with negative electricity the work done in bringing up unit positive charge will be negative, since there will be an attraction between the two charges, and instead of work being performed *on* the positive charge it will be performed *by* it. The potential of a negatively charged body is therefore negative, while an uncharged body is said to be at zero potential.

If a charged plate be connected by a conductor to another insulated and uncharged plate, a current will flow from the former to the latter, thus charging the second plate until both are at the same potential, the common potential, however, being lower than that to which the first plate had been charged. If V be the potential of the first plate and that of the second zero, the final common potential will be $\frac{V+O}{2}=\frac{V}{2}$. If, however, the first plate, at potential V, be connected to another plate charged with opposite electricity to an equal potential, viz. $-V$, the common potential will then become $\frac{V-V}{2}=O$, or the two charges will neutralise each other, the energy being expended in the discharge in the form of heat.

The earth being the "sink" into which all charges flow is therefore at zero potential, and any body charged with electricity will discharge this into the earth as soon as a conducting connection is formed between the two. It is this difference of potential between two bodies which supplies the driving force for the current to pass

from one to the other. The analogy with water applies again, difference of potential being analogous to difference in level, and just as the latter produces the "pressure" under which the water flows, so difference of potential produces a certain pressure under which electricity flows. Electricity will always flow from a body at a higher potential to one at a lower, but no such flow will occur between two bodies at the same potential, although each may contain quite a large charge of electricity. The greater the difference of potential between two bodies the greater or stronger will be the current produced. It is not actual quantity of electricity which is dangerous to life, but the potential or pressure under which it flows. Electric potential and current are connected by a simple law stated on p. 659. If the medium between two plates between which there exists a difference of potential is a conductor, as is the case with certain liquids, a current will pass through it, but if the medium, as in the case of air, is not a conductor (in which case it is termed a *dielectric*), no current will flow but instead, the medium is put into a state of strain. If the plates are brought closer together this strain is increased. Given a sufficiently large difference of potential and the plates sufficiently close together, the dielectric may break down under the strain and a sudden discharge in the form of a spark will then occur. This may be obtained with any of the old electrical friction machines, such as the Wimshurst, whereby two metal knobs are charged with opposite kinds of electricity, and when a sufficiently great difference of potential has been attained a series of sparks, very similar to a miniature display of lightning, is obtained provided the knobs are not too far apart.

Lightning.—The presence of an electric field of force in the atmosphere has been conclusively proved. How it arises is uncertain ; it has been suggested that it originates from evaporation or from friction between solid and liquid particles, or between masses of air at different temperatures. Whatever its origin, it accumulates in the clouds, and lightning is nothing but the discharge of electricity between two clouds or between a cloud and the earth's surface when the difference of potential has become so great that the resistance of the air has broken down under the strain.

A Lightning Conductor is a device for minimising risks to buildings during a discharge of lightning. It consists merely of a broad band of copper fixed to the outside of a building, with one end buried in the earth and the other running to a point (or set of points) projecting well above the structure. Its function primarily is to prevent an accumulation in the vicinity of the building of atmospheric electricity to which it offers an easy means of discharge as fast as it accumulates. This discharge is silent and harmless, as in the case of the two plates of the last figure when connected by a copper wire.

Wireless Telegraphy.—The spark discharge which takes place between two plates at different potentials and separated by a dielectric is not singular, but surges backwards and forwards from one plate to the other very many times in a second. Its oscillatory character may be shown either by means of revolving mirrors or by photographing the spark on a film fixed to the axle of a rapidly rotating electric motor. The result of these oscillations is to send out electric waves which are transmitted through the ether with the velocity of light. These are the waves that form the basis of wireless telegraphy, in which an electric current is sent surging up and down a long "aerial." A description of the ingenious instruments that have been devised for producing waves of great intensity and detecting them at a great distance from the source is beyond the scope of this article.

(2) Electricity Produced by Chemical Means or Voltaic Electricity.—This method dates back to about 1793, when Volta, professor of physics in the university of Pavia, first produced an electric current by such means.

If in a glass vessel containing dilute sulphuric acid we place two plates (Fig. 22), one of copper C and the other of zinc Z, and join them by a copper wire, an electric current will flow through the wire, plates, and liquid. Before a current is obtained, however, the circuit must be complete ; break the circuit at any point and the current ceases. This arrangement is called a *simple voltaic cell.* The two plates are termed the *poles* of the cell, the copper one being called the *positive* pole and the zinc the *negative.* The direction of the current is *assumed* to be from the positive to the negative pole through the wire and in the reverse direction through the liquid. This convention is unfortunate, as, according to modern theory, the current consists of negative atoms of electricity, or *electrons*, travelling from the negative to the positive pole through the wire, *i.e.* in a direction precisely opposite to the one hitherto assumed. The old assumption is, however, so firmly established that it is convenient to keep it.

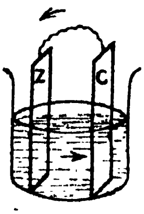


FIG. 22.

As long as the circuit is complete or "closed" a chemical action takes place represented by the equation

Sulphuric acid + zinc = zinc sulphate + hydrogen,

or symbolically

$$H_2SO_4 + Zn = ZnSO_4 + H_2,$$

an atom of zinc replacing the hydrogen in the sulphuric acid molecule. The zinc is gradually

dissolved by the acid and in course of time has to be renewed, and bubbles of hydrogen gas are given off which collect on the copper plate. The current is thus obtained and maintained apparently at the expense of the zinc, and it was thought at one time that the current was entirely the result of a change of chemical energy into electrical energy. A study of solutions, electrolysis (p. 666), and the passage of electricity through gases (p. 667) supplies, however, a more complete physical theory of the processes which take place within the cell. At this point it might be briefly stated that electricity resides in all matter and is already contained within the solution; the production, by friction, of a static charge of electricity on all substances, already suggests this, but the fact was not established until recent years. The act of solution itself, in some manner not yet properly understood, separates the H_2 molecules from the SO_4 molecules, and in the process of separation the latter become charged with negative and the former with positive electricity. Contact of the two metals with the solution produces a difference of potential between them[1] under the influence of which the SO_4 molecules are urged towards the zinc plate and the H_2 molecules towards the copper plate. There they give up their charges. But while doing this each SO_4 molecule combines with an atom of zinc, forming $ZnSO_4$. The current is proportional to the number of SO_4 molecules that have thus parted with their electric charges, and hence proportional to the amount of zinc dissolved. The closing of the circuit by the wire acts as a "trigger" to start the process, in so far as it provides a means of passage for the negative electric atoms to pass to the copper plate and there neutralise the corresponding positive charges. The current in the wire thus really consists of the passage of negative electricity from the zinc to the copper plate.

Other names in use for difference of potential are *electro-motive force* (written E.M.F. for short) and *voltage*. The voltage of a cell is therefore a measure of the strength of current such a cell will yield.

The deposition of hydrogen bubbles on the copper plate very soon weakens and then stops the current altogether, the gas reducing the effective contact between the copper and the acid. The cell is then said to have become *polarised*, but the polarisation rapidly diminishes as soon as the external circuit (the wire) is broken, and the cell then recovers its power. A simple cell, such as the one described, cannot therefore be used continuously, but only for very short intervals at a time.

Several types of such cells embodying improvements, chiefly with a view to diminishing polarisation, are now in use. It will suffice to describe but one of these, the Leclanché cell. In this the copper plate is replaced by a block of carbon closely packed with a mixture of small pieces of carbon and manganese dioxide in a pot of porous earthenware. This pot is placed in a glass jar containing a zinc plate or rod and a strong solution (3 in 20) of ammonium chloride (commonly called *sal-ammoniac*). The manganese dioxide absorbs the hydrogen bubbles which collect on the carbon and so minimises the polarisation effects. If, however, the cell is called upon to give current for many minutes at a time, the hydrogen is produced faster than it can be absorbed, and the power of the cell drops off, but is restored if allowed to rest. This cell does not require renewing for many months or even years, and is therefore very suitable for domestic purposes, such as electric bells, to give intermittent currents. Its voltage is about 1·5.

Dry cells, being more portable, have come into general use. They are, however, by no means dry; in fact their success depends largely on the contents being kept moist. They are all modifications of the Leclanché cell—a central carbon rod is surrounded by a paste consisting of a mixture of manganese dioxide, plumbago, and gum, the whole being in turn surrounded by a zinc cylinder with a thin paste of plaster of Paris and sal-ammoniac filling the intervening space.

Cell Battery.—If a number of cells are joined to form what is called a *battery* we naturally get a greater current than that given by a single cell. There are two methods of thus joining up a number of cells—either in "series" or in "parallel." The first or "series" method

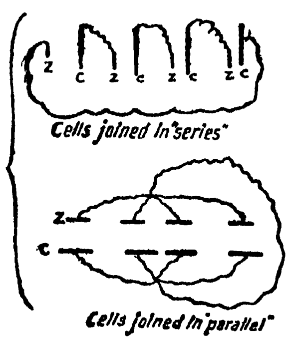


FIG. 23.

is to join the copper or carbon (as the case may be) of the first cell to the zinc of the second, then the copper of the second to the zinc of the third, and so on; finally the zinc of the first cell with the copper of the last. The second method, that of joining the cells in "parallel," is to connect all the zincs together to form, as it were,

[1] Contact difference of potential between copper and sulphuric acid is + ·46, while that between zinc and the same acid is − ·62, so that the total difference of potential in the cell is 1·08.

one large zinc plate, connect the coppers (or carbons) similarly, and then connect the two (Fig. 23).

Each method has its advantages. A calculation as to the strength of current produced by either arrangement can be made by an application of Ohm's Law, which must therefore be considered next. It must be remembered, however, that all the principles dealt with in the following pages hold true by whichever means—whether chemical or otherwise—an electric current is produced.

Resistance and Ohm's Law.—All substances, whether liquid, solid or gas, offer a resistance to the passage of an electric current. This resistance varies in magnitude with different substances. With good conductors the resistance is small; with poor conductors it is great. The better the conductor the smaller the resistance, but even the best conductors offer some resistance to a current. The result of such resistance is to cause heating, just as friction does in the case of mechanical energy.

The resistance of a substance is found not only to depend on the material but also directly on its length and inversely on its area of cross section. This is expressed by the equation $R = k\frac{l}{a}$ where R represents the resistance of the substance, l its length, a its area of cross section, and k a constant depending on the material and its temperature. k is called the *specific resistance* of the material, and is evidently equal to R when l and a are both equal to unity. In other words, the specific resistance of a substance is the resistance offered to an electric current by a bar of that substance 1 cm. in length and 1 sq. cm. in cross section. Evidently it is a knowledge of "k," or the specific resistance, that is required for purposes of determining the suitability or otherwise of any material to be used as a conductor. The substance with the smallest specific resistance is silver, next to that comes copper. As silver is expensive, copper is universally used for all electrical connections. It is well to remember that substances which are good conductors of heat are also good conductors of electricity. From the equation above it is also evident that if we wish to reduce the resistance through a circuit we must increase the area of cross section of the conductor; in other words, we must have the connections as thick as possible.

In the case of pure metals the specific resistance increases evenly, within certain limits, with increase of temperature. Having previously found the resistance of a wire at various known temperatures, it follows that the process may be reversed and temperature found by measurement of resistance. This is the manner in which the *platinum thermometer*, consisting of a platinum wire suitably encased, is used for measuring temperatures above 300° C. By its means the melting-points of metals up to 1000° C. have been determined, the mercury thermometer being quite useless for such purposes. Langley's bolometer for detecting and measuring radiant heat energy is constructed on the same principle.

The relation between strength of current and difference of potential was first investigated by G. S. Ohm, a German physicist, in 1826. From his experiments he deduced the law, now known by his name, that "in any wire at uniform temperature, the current is directly proportional to the potential difference (or electromotive force or voltage) between its ends." Expressing this law as an equation, if E represents the E.M.F. and C the current flowing through it, then $E = R.C$ where R is a constant depending on the material, length, thickness, and temperature of the wire, and which has come to be called the "resistance." Too much stress cannot be laid on the importance of this equation—the symbolic expression of Ohm's Law. It is the fundamental equation of the science of electricity and almost equal in importance to the equation $F = M.A$ (p. 626), which indeed it closely resembles, and which in its turn forms the basis of mechanics. Let us consider a few simple applications of Ohm's Law.

(*a*) To find the current that is obtained when a battery of cells is joined up either in series or in parallel. The total circuit is made up of cells and connecting wires. Let r be the "internal" resistance of each cell, that is of the portion of the circuit within the cell itself (through the plates and the liquid), and R the "external" resistance, *i.e.* that of the connecting wires. Let n be the number of cells used, and E the E.M.F. of each. Grouping the cells in series, the total E.M.F. is the sum of the E.M.Fs., or nE, and the total internal resistance will also be nr; the external resistance is R. Hence by Ohm's Law the current C obtained from such a grouping is, $C = \frac{nE}{R + nr}$.

If the internal resistance nr is great compared with the external, this grouping will give a small current, but the current will be at a high potential or "pressure" nE.

Joining in parallel—since this arrangement converts the whole into a single cell, but with plates n times as large as that of a single cell, the E.M.F. of such a grouping is only E (the same as that of a single cell), but the total internal resistance of the battery is reduced to $\frac{r}{n}$ of that of a single cell. The current C is therefore given by, $C = \frac{E}{R + \frac{r}{n}}$ or, $C = \frac{nE}{nR + r}$.

If R is small compared with r this grouping, therefore, gives a greater current than the pre-

vious arrangement, although at a lower potential E. But if R or the external resistance is great, as is the case in telegraphy where a long "line" is used, there is no advantage in reducing the total internal resistance. In fact the equation shows than an increase in the number of cells in parallel does not appreciably increase the current, which is in such a case approximately proportional to the number of cells connected in series. In the telegraph service, therefore, it is usual to link together a number of cells (from twenty to sixty) in *series*, and they are usually made up in boxes each containing a series of ten cells.

(*b*) The current at our disposal, viz., the "main," is too great for our purpose, which we will suppose is that of working an electrical magic lantern or a cinema machine. The excess of energy provided by the current over that required to work the machine, is spent in heating the wires, and if we connect the machine directly with the main these wires may fuse. The question, therefore, is how to reduce the current. The lights might be switched on and introduced into the circuit, but that, apart from obvious inconvenience, would be wasteful. Ohm's Law, however, suggests a means. The voltage we cannot alter—the current is always supplied at fixed pressure—but we can alter the resistance. If we introduce an additional resistance, apart from that supplied by the machine itself, the current will be reduced in accordance with the equation $E = RC$. The problem is thus solved by joining up a coil of *thin* wire in series with the machine.

(*c*) A current of strength C is flowing in a wire PQ. Another wire W is joined to the two points A and B forming a loop (Fig. 24). The

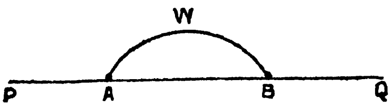


FIG. 24.

current on reaching A divides, part flowing through AB and part through W. It is required to find what *fraction* of the total current will flow through each. Let E be the fall of potential between A and B, r_1 the resistance of, and c_1 the current passing through, W; similarly, let r_2 and c_2 be the resistance and current through AB. Now the total current $C = c_1 + c_2$.

Also by Ohm's Law

$$E = c_1 r_1 \text{ and } E = c_2 r_2$$

$$\therefore c_1 r_1 = c_2 r_2$$

or

$$c_1 r_1 = (C - c_1)\, r_2$$

$$\therefore c_1 (r_1 + r_2) = C r_2$$

$$\therefore c_1 = C \frac{r_2}{r_1 + r_2} \quad . \; . \; . \; (1)$$

In the same way by substituting $(C - c_2)$ for c_1 we obtain

$$c_2 = C \frac{r_1}{r_1 + r_2} \quad . \; . \; . \; (2)$$

Equations (1) and (2) give the required fractions of the total current C, passing through W and AB respectively. Dividing equation (1) by (2) we get $\frac{c_1}{c_2} = \frac{r_2}{r_1}$, or the ratio of the currents is inversely proportional to the resistances, the greater portion of the current thus passing through the part of the loop with the smaller resistance. To take a concrete case, if the resistances are in the ratio of 3 : 2 then $\frac{3}{5}$ of the current will take the path of the smaller resistance, and $\frac{2}{5}$ of it will pass through the larger resistance.

The use of "shunts" is merely a direct application of this. We have a delicate electrical instrument, for example, which we wish to connect with the current in the wire PQ, and it is unwise to allow the whole of the current through it. The instrument takes the place of the section AB in the figure, and if an extra wire W is connected between A and B a portion of the current is then "shunted" through W. If a thick wire be used, then most of the current will take the path of least resistance and will pass through W and but a small fraction through the instrument itself, which is the result desired.

The Electro-Magnetic Field.—Clamp a piece of cardboard in a horizontal position; bore a small hole through its centre and pass a piece of copper wire vertically through it; sprinkle the cardboard with iron filings and pass a current through the wire. On tapping the cardboard the filings will arrange themselves in circles of which the wire forms the centre, thus giving the impression that there is a magnetic field surrounding the wire. If that is so a magnet needle in the vicinity of the wire ought to be deflected, and indeed it is. The passage of a current in a wire, or electricity in motion, is thus seen to be accompanied by a magnetic field (frequently called an *electro-magnetic* field since it is one caused by an electric current) surrounding the wire, the lines of force of the field being circles described round the wire as centre and with their planes perpendicular to the wire.

This field must not be confused with the electrostatic field which has no magnetic properties. It is electricity in *motion* which produces a magnetic field as an accompaniment; stationary electricity never does. It was Oersted of Copenhagen who first discovered, in 1820, the magnetic field as an invariable adjunct to an electric current. Ampère (1775–1836), a French professor of physics, investigating further, gave the following rule as to the direction of deflection of a magnet in the neighbourhood of an electric current:—"Suppose a man swim-

ming in the wire in the same direction as the current (assumed flowing from the positive to the negative pole) and with his face towards the magnet, the north-seeking pole will be deflected towards his left hand." Ampère's rule thus provides a means of determining the direction of a current by an observation of the direction in which a magnetic needle is deflected by it.

Further, the strength of the magnetic field surrounding the wire depends on the strength of the current, and consequently the amount by which a magnetic needle is deflected will provide a means of measuring this current.

Ampère's investigations into electro-magnetic fields led him to the following result:—If the direction of a very small length δl[1] of wire (Fig. 25) makes an angle a with a line joining it to a point P distant r from it, and the current in the wire is C, then the strength F of the field at P is given by, $F=\frac{C\delta l \sin a}{r^2}$. F is of course the force that would act on unit magnetic pole placed at that point. The application of this formula is very important. Consider a wire in the form of a circle of radius r (Fig. 26). It is required to find the strength of the field at the centre O, the current in the circuit being C. Now the line joining any point in the circle to the centre is at

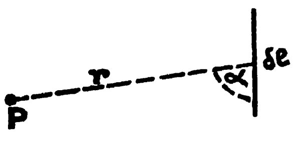


Fig. 25.

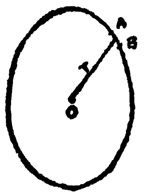


Fig. 26.

right angles to the wire at that point, and hence a in the formula is 90° and $\sin a = 1$. The strength F of the field at O due to a small length δl such as AB, is therefore $\frac{C\delta l}{r^2}$, and consequently the field F, due to the whole perimeter of the circle is, $\frac{C}{r^2}\times$ (sum of all such small lengths of wire contained in the circle).

The sum of all the small lengths such as AB is the total circumference of the circle, which is equal to $2\pi r$. Hence the strength F of the field at O is, $\frac{C}{r^2}\times 2\pi r$, which is equal to $\frac{2\pi C}{r}$.

If, however, instead of having an entire circle, we have a piece of wire 1 cm. in length, bent so as to form part of such a circle, the strength F of the field at the centre would then be $\frac{C}{r^2}$. This at once provides a definition of unit current, for if r be unity C is then equal to F. Unit current is therefore defined as *such a current that if flowing in the arc of a circle of which the radius is one centimetre, the length of the arc being also one centimetre, then the force exerted by that current on unit magnetic pole placed at the centre of the circle will be one dyne.* This is the c.g.s. unit of current. For practical purposes it is too large, and consequently $\frac{1}{10}$th of this is taken as the practical unit, which is called an *ampere.*

Other Units.—The unit of *quantity* of electricity is the quantity of electricity that passes any given point in a second when there is unit current flowing in the circuit. If the current is one ampere then the quantity just defined is the practical unit of quantity, and is called a *coulomb*, which is also $\frac{1}{10}$th of the c.g.s. unit of quantity. If the current is C, then the total quantity (Q) of electricity which passes any point in time t is given by $Q=Ct$.

Unit *difference of potential* or E.M.F. is such that the work done by unit quantity of electricity under this pressure is one erg. The practical unit, called a *volt*, is taken as 100,000,000 times the c.g.s. unit, or 10^8 c.g.s. units.

Since $E=CR$ (Ohm's Law), unit resistance is such that unit E.M.F. produces unit current. In practical units, if the E.M.F. is 1 volt and the current 1 ampere, the resistance is called an *Ohm*. Since a volt is 10^8 and an ampere is 10^{-1} c.g.s. units, an ohm must be 10^9 c.g.s. units.

From the definition of E.M.F. it follows that if Q coulombs of electricity are utilised at voltage V, the *work done* is VQ, and *Power*, which is work done in unit time, is therefore equal to $\frac{VQ}{t}$. But $\frac{Q}{t}=$ current C. Hence *Power* $= V\times C$, and *unit power* is obtained when a current of 1 ampere is conveyed at a potential difference of 1 volt. This practical unit is called a *watt*. (In c.g.s units 1 watt $=10^{-1}\times 10^8=10^7$ ergs per second, which is also called a Joule). Calculation shows that one horse-power $=746$ watts.

To find the power, therefore, that can be obtained from any supply, multiply the voltage (usually known, or it can be read from a voltmeter) by the current (which can be read from an ammeter); the product gives the power in watts. (A wattmeter will however read this product directly.) The Board of Trade Unit (B.T.U.) adopted for public supply is the *kilowatt-hour* (a kilowatt is 1000 watts).

Let us apply the above to a few simple practical examples, which will also serve as illustrations.

Example 1. What is the power (in watts, kilowatts, and horse-power) provided by a current of 90 amperes at 50 volts?

[1] δl is the notation employed to signify a minutely small length "l."

Power $= V \times C = 50 \times 90 = 4500$ watts.
$= 4{\cdot}5$ kilowatts.

$$= \frac{4500}{746} = 6{\cdot}03 \text{ horse-power.}$$

Example 2. A machine is driven for three hours by a current of 100 amperes at 80 volts. How many Board of Trade units have been used ?

Power $= 80 \times 100$ watts $= 8$ kilowatts.
$\therefore$ B.T. units used $= 8 \times 3 = 24$.

Example 3. What horse-power is required to drive a current of 80 amperes through a resistance of 10 ohms ?

E or V $=$ C $\times$ R (by Ohm's Law) $= 80 \times 10 = 800$ volts.

Power $=$ C $\times$ V $= 80 \times 800$ watts.

$$\text{Horse-power} = \frac{80 \times 800}{746} = 86 \text{ nearly.}$$

Example 4. The current passing through a lamp which absorbs $\frac{1}{8}$ horse-power is $0{\cdot}6$ ampere. What is the voltage required to work the lamp ?

$$\text{No. of watts absorbed by the lamp} = \frac{746}{8} \text{ watts.}$$

$$\text{Since } C \times V = \text{no. of watts, we have } {\cdot}6 \times V = \frac{746}{8}.$$

$$\therefore\ V = \frac{746}{8 \times {\cdot}6} = 155{\cdot}4 \text{ volts.}$$

Example 5. What is the candle-power of the lamp in the last example if $3{\cdot}25$ watts are required per candle-power ?

$$\text{Lamp absorbs } \frac{746}{8} \text{ watts} = 93{\cdot}25.$$

$$\therefore\ \text{candle-power} = \frac{93{\cdot}25}{3{\cdot}25} = 28{\cdot}7 \text{ nly.}$$

The Tangent Galvanometer.—On p. 661 it was shown that the strength of the magnetic field at the centre of a wire in the form of a circle of radius r and through which a current C is flowing is $\frac{2\pi C}{r}$. It follows that if instead of a single loop the wire is coiled in n loops, the strength of the field in the centre will be $\frac{2\pi nC}{r}$. It was also pointed out on p. 661 that the amount by which a magnetic needle is deflected by a current in a wire could be made to measure the strength of the current. We shall now consider how this is performed.

A very small light magnetic needle is suspended at the centre of a circular coil, and the needle is deflected through an angle α which can be read on a scale attached. On p. 654 it has been shown that if F is the force turning the magnet from the magnetic meridian, F $=$ H tan α.

$$\text{But } F = \frac{2\pi nC}{r} \qquad \text{Hence } \frac{2\pi nC}{r} = H \tan \alpha.$$

$$\text{and} \qquad C = \frac{rH}{2\pi n} \tan \alpha.$$

r, H, n are known, α is observed, and the value of tan α then obtained from a set of tables. Hence C can be calculated.

An instrument such as this for detecting and measuring the strength of a current is called a *galvanometer*, the particular form just described being called a "tangent" galvanometer for an obvious reason. In such an instrument r and n depend on its construction, while H is a constant quantity. Consequently the expression $\frac{rH}{2\pi n}$ is always the same for any particular instrument, and can be calculated and marked down once for all. If we write this as G, then the equation becomes C $=$ G tan α, G being a constant depending on the instrument.

The value of the current obtained from this formula is of course in c.g.s. units. Multiplying this value by 10 we get the current in amperes. The instrument can be graduated so as to read amperes straight off, thus obviating all calculations on the part of the observer. When constructed to do this, it is called an *ammeter*.

A precisely similar instrument, but with many coils of thin wire giving a resistance of many thousand ohms, will serve as a *voltmeter*. The internal resistance of a battery (or dynamo) is insignificant compared with this high resistance of the voltmeter, and hence by Ohm's Law the strength of the current which such a battery (or dynamo) can send through the instrument will depend only on the voltage between the ends of the coil in the instrument.

There are numerous kinds of galvanometers in use, but any attempt at a detailed description of them would very soon exhaust the limited space at our disposal. It must suffice to state that they all depend on the same principle, viz., that of a needle moving in a magnetic field either created by the current itself or by permanent magnets. Instruments intended for detecting very weak currents have attached, to the thread supporting the needle, a small mirror. A lamp is arranged in such a way that a spot of light is reflected from the mirror, on to a scale supported on a stand at some distance from the instrument. The slightest movement of the needle is by this means enormously magnified. These are called "mirror" galvanometers, the first of their kind being invented by Lord Kelvin for use in signalling through a long submarine cable through which the resulting current must be necessarily weak, on account of the great resistance such a cable presents.

Electro-magnet and Induction Coil.—If a wire

be coiled in a spiral and a current passed through it, the central space of this spiral will be filled by an electro-magnetic field, the strength of which will depend both on the strength of the current in the wire and on the number of turns of wire per unit length of the spiral. If now the wire be insulated by being wound with silk, or covered with gutta percha or any other non-conductor, and a cylinder of iron be introduced into it as shown in the figure, the iron core will become magnetised by induction as long as the current is flowing. If the cylinder be of soft iron, it will lose its magnetism as soon as the current is stopped and the electro-magnetic field thereby destroyed. Such a combination of an iron core and coil is called an *electro-magnet*, and has proved to be one of the most important of electrical devices, being extensively used in many practical applications.

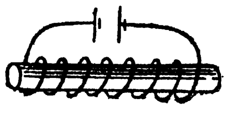


FIG 27.

Instead of the iron core let us place inside the spiral another coil, similar to it, and forming a complete circuit in itself, although in no way connected with the outer one, so that we have two independent circuits, an outer one called the *primary* and an inner called the *secondary*. If now we start a current through the outer coil, a *momentary* current, which ceases almost immediately, will be "induced" in the inner coil, as may be seen by connecting a galvanometer in the circuit of the latter. Break the current in the primary and again a momentary induced current will pass through the secondary, this time however in the reverse direction to that in which the induced current traversed it when the current was started in the primary. By "making" and "breaking" the current in the primary many times in a second an induced current practically continuous will be obtained in the secondary. But whereas the primary current is always in the same direction the induced current changes in direction as many times in a second as the primary is "made" and "broken." The induced current is therefore called an *alternating* current.

On starting a current in the primary, an electro-magnetic field is suddenly created, and when the current is stopped this is as suddenly destroyed. The nature and direction of the induced current in the secondary is such as to check or retard these sudden changes in the electro-magnetic field, and consequently induced currents are the manifestation of electrical inertia, the phenomenon being exactly similar to that observed in connection with matter when a force tends to change the state of rest or of motion of a body.

Michael Faraday (1791–1867), originally a bookbinder's apprentice, who became the foremost scientist of his day, and whose investigations laid the foundations of modern industrial applications of electricity, was the discoverer of these induced currents, and enunciated the law (known as Faraday's Law) that "the E.M.F. of the induced secondary current is equal to the *rate* at which the lines of magnetic force due to the primary current are created or destroyed." By having a few coils of thick wire to constitute the primary circuit and a large number of coils of thin wire to form the secondary, a current of low potential in the primary will induce one of high potential in the secondary. The Ruhmkorff induction coil is an instrument constructed on these principles, and changes a direct, low potential current into an alternating current at a high potential.

PRACTICAL APPLICATIONS OF THE ELECTRIC CURRENT

The Electric Bell.—In this instrument the current is provided by one or two Leclanché cells, the circuit being closed by pressing the "push." The bell contains an electro-magnet which attracts a light piece of iron, called an armature. As this armature moves towards the electro-magnet the circuit is broken, the electro-magnet is immediately demagnetised, and the armature is drawn back to its original position by a spring. The circuit is now again complete and the movement repeated. The armature is attached to a "striker" or hammer, and its movements backwards and forwards "ring" the bell.

The Telegraph.—The circuit consists of a battery of cells (see p. 660), the "line" and the earth, the latter being used for the "return," which effects a saving in wire, one pole of the battery being attached to a plate buried in the earth, the other to the "line," the extreme end of which also terminates in a plate buried in the earth. A "key" is connected into the circuit; on pressing this key down the circuit is completed and a current flows through the wire, which is of copper slung between poles, but supported on insulating cups made of porcelain. The receiving apparatus consists of a small electro-magnet called a *Morse Sounder,* which acts in the manner just described for the electric bell. The clicks made by the armature in striking the pole of the magnet constitute a series of well-known signals known as the Morse Code.

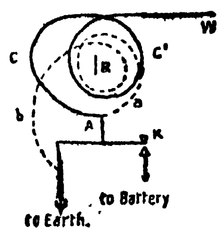


FIG. 28.

In Duplex telegraphy, now in common use, a device in winding is used whereby messages, one in each direction, can be sent over the same wire simultaneously. This is shown in Fig. 28. On pressing down the key K the current divides at A, part travelling along *Aab* and part along

ACC′W. By making the resistances of these two circuits equal, the same strength of current will flow through each, and as these currents travel round the transmitter's receiving instrument R in opposite directions, the latter will not be affected. But it *will* be affected by a current sent from the other end of the wire W, there being only one path WC′CA for such a current.

Submarine Telegraphy.—Precisely the same principles apply. Very great care must, however, be taken to insulate the wire called *the cable*, which is laid on the sea bed, from contact with the water. A sensitive mirror galvanometer, however, takes the place of the Morse Sounder as a receiving instrument.

The Telephone consists of two pieces of apparatus (*a*) the *transmitter*, which is spoken into, and (*b*) the *receiver*, which reproduces the sounds, the two being joined by wires to form an electric circuit, in which a current is maintained by batteries of cells, or by a dynamo at a central station. The transmitter (Fig. 29) contains an iron diaphragm D fixed across a mouth-piece M′; a platinum wire W is supported by a spring S so as to touch lightly both the diaphragm D and a piece of carbon C. On speaking into the mouth-piece the sound vibrations cause the diaphragm to vibrate in unison, and thus vary

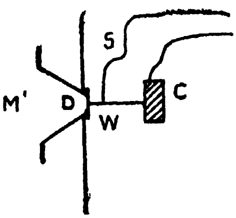


FIG. 29.

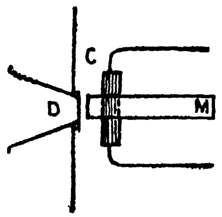


FIG. 30.

the pressure with which the wire presses against the carbon. These pressure variations introduce changes in the electrical resistance of the circuit with consequent changes in current which affect the receiver (Fig. 30). This latter, which is placed to the ear, contains a diaphragm D with one pole of a permanent steel magnet M close to it. Surrounding the pole is a coil C with its ends connected to the "line." The magnet affects the diaphragm, and when variations in the current are produced in the manner just described, changes are produced in the magnetic induction of the coil with consequent changes of pole strength of the magnet, which set the diaphragm vibrating in accordance with these changes. Thus the diaphragm in the receiver reproduces exactly the vibrations of the diaphragm in the transmitter, and consequently the sounds.

Electric Lighting and Heating.—Since the work done in unit time by current C at voltage V is equal to VC this is also the energy available for heating purposes. But V = RC (Ohm's Law), hence the heat to be derived is equal to RCC or RC^2 in unit time, and at end of time t the heat generated will be RC^2t. This is quite independent of whether the current is continuous (always flowing in the same direction) or alternating. The heat depends only on the resistance and on the square of the strength of current. If the energy of the current is not utilised for industrial purposes or for lighting lamps, it will be dissipated in heating the wires in the circuit. If the wires in the main are permitted to touch, a "short circuit" will be formed in which all the energy is expended as heat, and unless the mains are protected they will instantly melt. "Fuses" or thin wires of lead are therefore placed at convenient points, so that if the current rises above a certain value these melt, and in so doing break the circuit and protect the mains from injury.

This heating effect of the current is utilised for purposes of electric lighting and heating. The electric incandescent lamp contains very thin filaments of a substance such as carbon, which is not a good conductor. The thinner the filament the greater the resistance it offers to the current, and by doing so it gets heated to whiteness and emits a brilliant light. The filaments of the modern metal incandescent lamps are made of the rare metals osmium, tantalum, and tungsten; and as the temperatures developed in them are some hundreds of degrees greater than in the carbon filament, they are much more efficient. The metal filament lamp requires about 1 watt per candle-power of light, while the carbon filament requires about 3½ watts. To prolong the life of the filaments they are enclosed in glass bulbs from which the air has been exhausted.

The arc lamp, although based on the same principle of resistance to a current, is however different in structure. It contains two carbon rods which are *first* brought into contact and then separated for a short distance. The current then continues to pass across the small air gap thus formed, but as air is a poor conductor this gap offers a great resistance, with the result that at this point an intense light is emitted owing to the great heat generated. The ends of both carbons are slowly destroyed and the gap increases. When this becomes too great the current will cease, being no longer able to bridge the gap. Hence such a lamp must be fitted with a device (usually some form of electromagnet) whereby, directly the current ceases, the rods are first brought together and then separated again to the correct distance. Arc lamps, however, produce carbon vapour, which makes them unsuitable for anything but outdoor use.

Space does not permit of a description of electric radiators, electric cooking utensils, &c., but the principles on which they depend are all the same as in the case of lighting, the variations being merely in the form of device adopted.

(3) Electro-magnetic Method of Producing Electricity.—Cell batteries are quite inadequate to provide current in bulk for lighting houses, streets, &c., or for power for industrial purposes. The current is produced by electro-magnetic means.

Currents Induced by Magnets.—We have seen how the starting and stopping of a current in one circuit will "induce" a current in another, and that the induced current is due to changes in the electro-magnetic field of the first. Now a change in a magnetic field can be obtained by merely moving a magnet, and this suggests that we ought to be able to induce a current in a circuit either by the motion of a magnet in its neighbourhood or by the motion of the circuit itself through a magnetic field. This suggestion is still further strengthened by the observed fact that electricity in motion produces magnetism; will magnetism in motion produce electricity?

Faraday was the first to try this, and with complete success, as long ago as 1831. He connected a coil of insulated wire with a galvanometer, and on moving a magnet in and out of the hollow of the coil he found that the galvanometer needle was deflected in one direction when the magnet was inserted into the coil, and in the opposite direction when it was removed from the coil; as long as the magnet was kept still, whether in or out of the coil, there was no deflection of the galvanometer.

It follows from Faraday's Law (p. 663), that the E.M.F. of the induced current depends directly on the rapidity of motion of the magnet. Also since the induced current is such as to tend to stop the changes in the magnetic field it will also tend to stop the motion of the magnet. Hence beside the energy expended in the actual movement of a mass equivalent to the weight of the magnet, additional energy has to be spent in overcoming the opposing force due to the induced current. It is this additional mechanical energy which becomes converted into electrical energy in the form of an induced current, the two are exactly equal, but the electrical energy is in a more convenient form, capable of being transferred to a distance from the spot where it is generated, and there utilised.

The Dynamo.—The history of the electrical industry is the history of the development and adaptation of Faraday's simple experiment of 1831 to its present practical form in the dynamo and motor. A *dynamo* is a machine for the production of current in bulk. Instead of moving a magnet in and out of a coil, as Faraday did, the same result is obtained by revolving a coil between the poles of a magnet bent in the form of a horse shoe. In the modern dynamo an armature (which is an iron core wound with a series of coils of wire) is revolved by a steam or gas engine or water-power, in a strong magnetic field provided by one or more electro-magnets; as the coils of the armature cut the magnetic lines of force a current is induced in them.

Part of the current thus produced is utilised to magnetise the electro-magnets, whose magnetism thus increases in intensity with increase of current until the maximum strength of current is obtained.

The operation of an electric motor is the reverse of that of a dynamo; the two are very similar in construction. The current supplied to the motor causes the rotation of an armature, the mechanical energy of which is then utilised.

The characteristics of the current produced by a dynamo might be studied by moving a single loop of wire in a magnetic field. Bend a wire into the form of a rectangle, connect it to a galvanometer, and support it in a vertical plane at right angles to the magnetic meridian, so that the lines of force of the earth's magnetic field pass through it in the direction of the arrow (position 1). Turn it quickly through any angle and a current will be induced which will be indicated and measured by the galvanometer. Trial will show that the greatest current is induced when it has been turned through a right angle into position 2, in which position no magnetic lines of force pass through it.

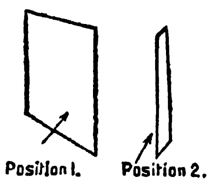


FIG. 31.

It may be proved that if A is the area of the coil, H the strength of the magnetic field, θ the angle through which the coil has been turned, and w the angular velocity with which the rotation has been performed, then the induced E.M.F. $= w\text{AH} \sin \theta$[1].

The E.M.F., w, A, and θ can all be measured. Hence such a coil can be, and is, used for the purpose of measuring H.

Now when θ is zero, $\sin \theta = 0$; when θ is 90° $\sin \theta = 1$; when θ is 180°, $\sin \theta = 0$; when θ is 270°, $\sin \theta = -1$; and when θ is 360,° $\sin \theta = 0$. Hence as the coil makes a complete revolution the induced E.M.F. changes from zero to a maximum value equal to wAH, then to zero again, then to $-w$AH (*i.e.* wAH in magnitude, but reversed in direction), and then back to zero again. The current is therefore not only alternating, changing in direction during the

[1] If N is the number of lines of magnetic force threading the coil when in position 1, then N = AH, and in any position making an angle θ with the first, N = AH $\cos \theta$.

By Faraday's Law the induced E.M.F. $= -\frac{dN}{dt}$, t being the time in which N lines of force are cut.

$\therefore$ the induced E.M.F. $= \text{AH} \sin \theta \frac{d\theta}{dt}$ (by differentiating AH $\cos \theta$).

But $\frac{d\theta}{dt} = w$ $\qquad \therefore$ E.M.F. $= w\text{AH} \sin \theta$.

course of a revolution of the coil, but also varies in strength, rising from zero to a maximum and back to zero again.

Such is the current produced by a dynamo. It is to be noted that the voltage depends not only on H, the strength of the magnets, but also on w, the speed with which the armature revolves. But as the armature revolves very many times a second, this variation in voltage is so rapid that for practical purposes it may be reckoned as constant and equal to the average (that between zero and the maximum) voltage—actually the voltage is equal to $\frac{2}{\pi} \times$ maximum voltage.

Now for lighting and heating either an alternating or continuous current will do, but for traction a continuous one is required. Dynamos producing current for the latter purpose are, therefore, fitted with a device called a *commutator* for changing the alternating current into a continuous one. The device, though ingenious, is simplicity itself. Two copper semicircular rings separated by gaps ab and cd (Fig. 32) are fitted to the revolving armature, the current being taken from the brushes A and B in contact with them. *The rings are fixed in such a manner that when the gaps cross the brushes, the current is zero.* When the ring ac is at the higher potential, the current flows from brush A; as the armature revolves in the direction of the arrow mark, the current decreases until the gap cd crosses the brush, when it becomes zero; the current then reverses in direction, the ring bd being now at the higher potential; but bd is now in contact with A, and consequently the current will still flow from A until the gap ab is crossed, when the same process is repeated and the current thus flows continually in the same direction—from A to B.

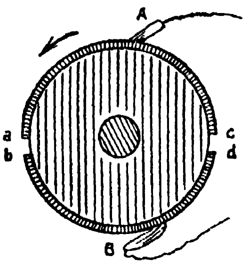


FIG 32.

Chemical Effects of the Electric Current.—Not only do certain chemical combinations produce an electric current, but the reverse is also true—a current will produce chemical effects. Pure metals, whether solid or liquid, conduct electricity without undergoing any chemical change. Many liquids, however, such as dilute acids, solutions of metallic salts, and certain fused compounds, also conduct an electric current, but are at the same time decomposed by it. These are called *electrolytes*, and the process of decomposing them by an electric current is known as *electrolysis*.

The current is passed through an electrolyte by immersing two metal rods or plates in it, one connected to the positive pole and the other to the negative pole of a cell or battery. The former plate is termed the *anode* and the latter the *kathode*; both are termed *electrodes*. During the passage of the current the electrolyte is decomposed into two elements or groups of elements called *ions*, one being liberated at the anode and termed the *anion*, and the other at the kathode and termed the *kation*.

Pure water will not conduct electricity, but if slightly acidified it will act as an electrolyte, not only conducting the current but being decomposed into its constituents hydrogen and oxygen, which are given off at the electrodes, the former at the kathode and the latter at the anode.

In the majority of cases the chemical actions are not as simple as would appear from the electrolysis of water. With a solution of copper sulphate or "blue vitriol" as the electrolyte, metallic copper is deposited at the kathode and oxygen at the anode, provided the electrodes are both of platinum. But copper sulphate is not a compound of copper and oxygen; it is a compound of copper, sulphur, and oxygen, its chemical formula being $CuSO_4$ (a combination of 1 atom of copper, 1 of sulphur, and 4 of oxygen). The chemical reactions which take place may be represented by the following: $CuSO_4 = Cu + SO_4$, the copper being liberated at the kathode and the SO_4 ion at the anode; the latter then immediately combines with the water contained in the solution in its immediate neighbourhood: $SO_4 + H_2O = H_2SO_4 + O$, with the result that oxygen is liberated at the anode and the (sulphuric acid) solution becomes richer in sulphuric acid as the process goes on. If copper electrodes are used no oxygen is given off at the anode; the SO_4 ion in that case combines with the copper of the anode to form $CuSO_4$, so that the copper anode itself dissolves away into the liquid at exactly the same rate as copper is deposited on the kathode, the strength of the solution of copper sulphate remaining unaltered —the final result in this case being merely a transference of copper from the anode to the kathode, which becomes "electroplated" or covered with a thin layer of copper not easily removed.

Faraday's Laws of Electrolysis.—Faraday, who investigated the subject in 1833, deduced the following two laws:—

(1) The mass or quantity of an electrolyte decomposed is proportional to the quantity of electricity which passes.

(2) The mass of an ion liberated by any given quantity of electricity is proportional to the chemical equivalent weight of the ion.

By "chemical equivalent weight" of an element is meant the weight of that element which will combine with, or replace, one atom of hydrogen. Thus in the case of copper as a cupric salt ($CuSO_4$), one atom of copper replaces two of hydrogen (*cf.* $CuSO_4$ with H_2SO_4), and since

the atomic weight of copper is 63, its chemical equivalent weight will be 31·5. In cuprous salts of copper its chemical equivalent weight is 63.

If m is the mass of any substance liberated by a current C in time t, and P its chemical equivalent weight, then from Faraday's Laws $m = k\text{PC}t$ where k is a constant. When C and t are each unity $m = k\text{P}$. The quantity $k\text{P}$ is termed the *electro-chemical equivalent* weight of that substance, and is therefore defined as "the weight (in grams) of the substance deposited by unit current (1 ampere) in unit time (1 second), or the weight deposited by 1 coulomb of electricity." Knowing the electro-chemical equivalent of any substance we know exactly the mass of that substance which will be deposited by any known current in any given time.

The accurate determination of this quantity, for at least one element, is therefore a very important matter, since knowing this we can calculate the electro-chemical equivalents for all other substances in accordance with Faraday's Second Law, whereby the electro-chemical equivalents of any two substances are proportional to their chemical equivalent weights, which are known. This determination was made for silver, and its electro-chemical equivalent weight was found to be ·001118. The chemical equivalent of silver is 107, and hence the electro-chemical equivalents of other electrolytic substances can be calculated. A number of them are given in the following table :—

Electro-chemical Equivalents.

Silver	·001118
Hydrogen	·000010
Oxygen	·000083
Aluminium	·000094
Iron (Ferric)	·000193
„ (Ferrous)	·000289
Copper (Cupric)	·000329
„ (Cuprous)	·000659
Sodium	·000239
Nickel	·000304
Zinc	·000339
Chlorine	·000367
Potassium	·000406
Gold	·000681

Electrolysis has now important industrial applications. The Castner process of manufacturing caustic soda and chlorine consists in the electrolysis of common salt. By a similar process sodium is obtained from caustic soda. Aluminium is now manufactured by the electrolysis of fused cryolite and alumina, and so with many other industrial processes for the isolation and refining of metals.

Electroplating is another important adaptation. The article to be plated is made the kathode, and is immersed in a bath containing a solution of a salt of the metal with which it is to be covered; the anode consists of a bar of the same metal as that contained in the salt. *Electrotyping* is the electroplating of a plaster, wax, or gutta-percha mould coated with plumbago to act as a conductor.

Theory of Electrolysis.—At first sight it would seem as if the ionisation, *i.e.* the separation of a molecule into two ions, in an electrolyte is a result of the energy supplied by the electric current. The results of experiments prove that Ohm's Law is obeyed in an electrolyte just as it is in the case of a metal conductor, and, further, all the energy of the current is converted into heat and not partly into heat and partly into chemical change. This heat is, of course, absorbed by the ions, and reappears as such in any future recombination of these ions. Since during such recombination very different quantities of heat are evolved by different elements, it follows that before decomposition of an electrolyte can take place a certain minimum quantity of heat must first be developed by the current. As the heat developed by current C, in unit time, is equal to VC, the necessary minimum potential difference V must vary with different electrolytes. In other words, an electrolyte cannot be decomposed until a certain minimum difference of potential exists between the electrodes.

The question now arises—if no part of the energy of the current is spent in separating the ions from each other, how is the ionisation effected? Since the substance which is decomposed is in a state of solution, the answer must be sought in a study of problems connected with solutions. Investigations in this field of inquiry show that the ionisation of an electrolyte is produced in the act of solution itself. Further, to explain the observed facts, we must assume that with each ion there is associated an electrical charge, positive in the case of the kations and negative in the case of the anions. The differently charged ions then drift towards the electrodes (to which they finally give up their charges) under the influence of a potential difference which is, therefore, merely *directive*, and no expenditure of energy is necessary for chemical work within the solution. The charge associated with each ion constitutes a true natural unit of electricity; no smaller unit seems capable of existing.

Passage of Electricity through Gases.—After studying the passage of electricity through solids and liquids the next natural step is to investigate the phenomena and laws connected with the passage of electricity through gases.

This may be carried out by fixing inside the ends of a long glass tube, filled with a gas, two metal electrodes connected to an induction coil; the tube is also connected with an air pump, or, better still, a mercury pump. When a sufficiently large difference of potential is set up between the electrodes the current passes in the

form of a spark discharge. By experimenting with this apparatus, called a *vacuum tube*, it will be found that the minimum potential difference necessary to produce the spark varies with the distance between the electrodes, with their shape, and chiefly, with the pressure of the gas. As the pressure is reduced by the pump the difference of potential required decreases at first until a certain critical pressure is reached, depending on the distance between the electrodes. As the pressure is still further decreased, the necessary potential difference increases until, at the highest vacuum attainable, it is practically impossible to produce a spark.

When the rarefaction in the tube is not very great, a luminous column giving a beautifully brilliant light and called the *positive column* extends in a straight line between the electrodes. As the pressure of the gas is reduced the positive column breaks up, leaving dark gaps, and when the rarefaction is very high and about a millionth part of one atmosphere, a dark space extends throughout the tube, and a phosphorescent light (a beautiful pale green glow) appears on the surface of the glass. Under these latter conditions the phenomenon has been fully investigated by Crookes, Lenard, and others. They found that the tube is filled with rays, called *kathode* rays, proceeding from the kathode in straight lines perpendicular to its surface. Thus an obstacle fixed in the tube in the path of the rays throws a shadow on the glass; a wheel fitted with vanes will be made to rotate if only half of it is placed in the path of the rays; the rays possess the property of heating bodies on which they impinge; if the kathode is spherical, so that the rays focus at a point, a piece of platinum placed at that point will be heated to redness. Most important of all, the rays are deflected by a magnetic field.

All these facts go to prove that the kathode rays are a stream of electrically charged and infinitely small particles, called *corpuscles* or *electrons*, shot out from the kathode with great velocity—a sort of stream of tiny bullets producing phosphorescence, heating and mechanical effects by their impact.

The direction in which they are deviated by the pole of a magnet proves them to be charged with what has been conventionally termed negative electricity.

Röntgen or X Rays.—These were discovered by accident in 1895. Professor Röntgen found that a photographic plate accidentally lying near the "vacuum" tube with which he was experimenting was affected by the kathode rays. Investigation showed that when the electrons are stopped by the anode they produce ether pulses or waves which have been called Röntgen, or X rays, and which are propagated with the velocity of light, and are capable of penetrating substances (such as black paper) which are opaque to ordinary light. With a tube fitted with a concave kathode and an additional anode called an *anti-kathode*, made of platinum and placed at the centre of curvature of the kathode, so that the electrons are focussed on to it, X rays of greater potency are obtained—rays capable of penetrating many solid substances. The transparency of a substance to these rays depends merely on its density. The bones and denser parts of the body are less transparent than the flesh, and thus photographs can be made which clearly show, through the flesh, the details of the bones and denser parts of the body. The rays excite powerful fluorescence in barium platino-cyanide, and if a screen coated with this substance be placed in their path and the hand interposed, the fluorescence on the screen is less marked where the rays have been absorbed by the bones, and a shadow of them is thrown on the screen. X rays are now an invaluable aid to surgeons and physicians, enabling them to locate fractures and growths in the body.

Electron Theory.—The advent of the electron has begun a new epoch in the history of physical science. Its properties and the phenomena observed in connection therewith require a readjustment of our conceptions of the nature of matter.

In a series of brilliant experiments, Professor J. J. Thomson succeeded in weighing an electron and in measuring both the velocity with which it leaves the kathode of the vacuum tube and the electric charge it carries. He found that its mass was equal to about $\frac{1}{1000}$th part of that of the lightest known atom—the hydrogen atom. (More recent determinations show that the mass of the electron is only $\frac{1}{2500}$th part of that of the hydrogen atom.) The velocity with which the electron moves is equal to about $\frac{1}{5}$th that of light, and the electric charge associated with it is $1{\cdot}13 \times 10^{-20}$ c.g.s. units or $1{\cdot}13 \times 10^{-21}$ amperes. This charge, it is important to note, is the same as that found associated with a single hydrogen atom in the process of electrolysis, and is evidently the smallest possible quantity of electricity obtainable. Electricity, like matter, is therefore not infinitely divisible.

The electrons are the result of a splitting up of the gaseous atoms at the kathode of the vacuum tube. They are therefore part of the atom, which cannot be as simple in structure as was hitherto supposed. But what is an electron? It is evidently not a material particle, and yet possesses mass or inertia, a property which has hitherto been exclusively associated with matter; in fact matter has been defined as "that which possesses mass." Lorentz and Larmor have, however, demonstrated mathematically that a free charge of electricity in rapid motion would, owing to the magnetic field associated with it, possess mass or inertia. The mass of an electron thus elucidated, an electron becomes *an atom of*

free electricity, of the kind conventionally termed negative, in some way connected with the material atom and capable of being, under certain conditions, freed and expelled from it. Is there a corresponding positive electron associated with the atom and which neutralises this negative one? The answer at present is that there is not, or if there is, physicists have not succeeded in isolating it, as positive electrons are invariably found to be of molecular size.

The present hypothesis is, that an atom contains a large number of electrons, compared with which the atom itself is a vast structure with great open spaces through which the electrons move. Sir Oliver Lodge has compared the electrons in an atom with flies in a cathedral. The electrons are in rapid orbital motion, each revolving within the atom in an orbit of its own, similar to the revolutions of the planets about the sun, and subject to laws exactly analogous to Kepler's laws for the planets. The wave length and frequency of the wave motion constituting light require the period of revolution of an electron to be inconceivably rapid—many thousands of billions of revolutions in a second.

An atom with its full complement of electrons is, in some manner not yet understood, electrically neutral; when an electron is freed from the atom, it attaches itself to a neighbouring atom or molecule which then becomes negatively charged, while the original atom minus the electron exhibits a corresponding charge of positive electricity. The two kinds of electricity are thus merely an excess or defect of the same thing. A current of electricity, whether through a solid, liquid, or gas, is thus not produced from outside the conducting medium, but consists of a swarm of electrons freed, under the influence or pressure of an electromotive force, from the atoms of the medium itself, and through which they move from atom to atom, thus carrying the current with them. This swarm is, however, a minute quantity compared with the actual number of electrons contained in the substance. In the dynamo, for instance, the thrusts which the electrons in the coils experience as the latter cut the lines of force of the electro-magnets, set them free and urge them along the wire round the circuit, the kinetic energy of the moving coils being changed into kinetic energy of moving electrons.

Another question now arises: Is the inertia of matter a different thing from the inertia of electricity or are the two the same, in which case we should have to assume that the atoms of matter are in some unknown way entirely composed of electrons? Over eighty kinds of material atoms have been differentiated, but so far we only know one kind of electrical atom —the electron. Are all forms of matter then merely various compounds of this elementary substance—free electricity? The property of inertia exhibited by matter lends colour to this hypothesis, which is further supported by another line of reasoning. If the material atom is entirely composed of electrons and does not merely contain a certain number associated with it, then the difference between one element and another must be merely due to a difference in number and arrangement of the electrons in the atom. In such a case, it is possible that a number of electrons may, from time to time, be discharged from the atom and leave the remaining electrons in an unstable state, requiring rearrangement. This, in turn, suggests the occasional instability of matter and consequent change from one form to another—a form of evolution of inanimate matter comparable to the theory of evolution of animate matter, now generally accepted.

It is a line of reasoning suggested by, and finding support in, the phenomena of radioactivity exhibited by many substances, and, in an intensified form, by radium and its compounds. Such a theory, fascinating as it is, has, in the view of Professor Soddy, one of the leaders in this line of research, "Altogether too serious consequences for the whole of the human race to be lightly assumed . . . and it is best not to be in too great a hurry to abolish the old distinctions between atoms." In other words, it is best to keep an open mind until more knowledge is obtained—knowledge which depends on the answer to the crucial question: What is positive electricity? Free electricity is remarkably powerful, and the actual quantity of such free electricity involved in any electrical manifestation is insignificant. To quote Professor Soddy again, "Suppose we take as many electrons (7×10^{23}) as there are atoms in a gram of hydrogen . . . this charge would, if free, charge the whole world up to a potential of a million volts . . . if two such quantities of electricity were placed, one at the north and the other at the south pole of the earth, they would . . . even at this distance, repel each other so strongly that it would require a fairly thick steel cable, capable of supporting the weight of 35 tons, to keep them from moving apart." What is the force then which keeps the similarly charged electrons of an atom together? In other words, what is the agent which neutralises the mutually repulsive forces which must exist within the atom of an electrically neutral substance, and without which the atom would be explosively dismembered?

Such is the question at present awaiting an answer—an answer which will take us a long way towards the solution of the great mystery of the constitution and structure of matter.

USEFUL DATA AND TABLES

1 Metre = 39·37 inches.
= 3·281 feet.
= 1·093 yards = $\frac{12}{11}$ yards (approximately)
1 Yard = 0·91438 metre.
1 Square Metre = 10·76 square feet.
1 Cubic Metre = 35·3 cubic feet.
1 Gramme = 15·43 grains.
1 Grain = 0·0479 grammes.
1 Kilogramme = 2·2 lbs. (approx.).
1 Litre = 61·027 cubic inches.
1 Litre of water at 4° C. weighs 1 kilogramme.
1 Kilometre = 1093·6 yards.
8 Kilometres = 5 miles (nearly).
π (the ratio of the circumference of a circle to its diameter) = $\frac{22}{7}$, or more nearly 3·1416
Area of a circle = πr^2 (r = radius)
Circumference of a circle = $2\pi r$.
Volume of sphere = $\frac{4}{3}\pi r^3$

The *Specific Gravity* of a substance is the ratio of the weight of any volume of that substance to the weight of an equal volume of water.

Substance	*Specific Gravity.*
Gold	19·25
Brass	8·39
Iron (wrought)	7·79
„ (cast)	7·21
Plate glass	2·37
Marble	2·84
Cork	0·24
Milk	1·03
Mercury	13·596

TRIGONOMETRICAL RATIOS

$$\text{Hypotenuse} = \sqrt{(\text{Intercept})^2 + (\text{Perp.})^2}$$

$$\text{Sin A} = \frac{\text{Perp.}}{\text{Hypot.}}$$

$$\text{Cos A} = \frac{\text{Intercept}}{\text{Hypot.}}$$

$$\text{Tan A} = \frac{\text{Perp.}}{\text{Intercept}} = \frac{\text{Sin A}}{\text{Cos A}}$$

Angle.	Sin.	Cos.	Tan.	Angle.	Sin.	Cos.	Tan.	Angle.	Tan.
0°	·0	1·0	·0						
1°	·01745	·99985	·01746	31°	·51504	·85717	·60086	61°	1·80405
2°	·03490	·99939	·03492	32°	·52992	·84805	·62487	62°	1·88073
3°	·05234	·99863	·05241	33°	·54464	·83867	·64941	63°	1·96261
4°	·06976	·99756	·06993	34°	·55919	·82904	·67451	64°	2·05030
5°	·08716	·99619	·08749	35°	·57358	·81915	·70021	65°	2·14451
6°	·10453	·99452	·10510	36°	·58779	·80902	·72654	66°	2·24604
7°	·12187	·99255	·12278	37°	·60181	·79864	·75355	67°	2·35585
8°	·13917	·99027	·14054	38°	·61566	·78801	·78129	68°	2·47509
9°	·15643	·98769	·15838	39°	·62932	·77715	·80978	69°	2·60509
10°	·17365	·98481	·17633	40°	·64279	·76604	·83910	70°	2·74748
11°	·19081	·98163	·19438	41°	·65606	·75471	·86929	71°	2·90421
12°	·20791	·97815	·21256	42°	·66913	·74314	·90040	72°	3·07768
13°	·22495	·97437	·23087	43°	·68200	·73135	·93252	73°	3·27085
14°	·24192	·97030	·24933	44°	·69466	·71934	·96569	74°	3·48741
15°	·25882	·96593	·26795	45°	·70711	·70711	1·0	75°	3·73205
16°	·27564	·96126	·28675	46°			1·03553	76°	4·01078
17°	·29237	·95630	·30573	47°			1·07237	77°	4·33148
18°	·30902	·95106	·32492	48°			1·11061	78°	4·70463
19°	·32557	·94552	·34433	49°	Since Sin A = Cos (90°—A) and Cos A = Sin (90°—A) the Sines and Cosines of angles from 46° to 90° can be found from above.		1·15037	79°	5·14455
20°	·34202	·93969	·36397	50°			1·19175	80°	5·67128
21°	·35837	·93358	·38386	51°			1·23490	81°	6·31375
22°	·37461	·92718	·40403	52°			1·27994	82°	7·11537
23°	·39073	·92050	·42447	53°			1·32704	83°	8·14435
24°	·40674	·91355	·44523	54°	For example :—		1·37638	84°	9·51436
25°	·42262	·90631	·46631	55°	Sin 53° = Cos (90°—53°) = Cos 37° = ·79864		1·42815	85°	11·43005
26°	·43837	·89879	·48773	56°	Cos 64° = Sin (90°—64°) = Sin 26° = ·43837		1·48256	86°	14·30067
27°	·45399	·89101	·50953	57°			1·53986	87°	19·08114
28°	·46947	·88295	·53171	58°			1·60033	88°	28·63625
29°	·48481	·87462	·55431	59°			1·66428	89°	57·28996
30°	·5	·86603	·57735	60°			1·73205	90°	Infinite.

For angles between 90° and 180° :—
Sin A = Sin (180°—A).
Cos A = —Cos (180°—A).
Tan A = —Tan (180°—A).
They can therefore be found from this table.
Examples :—Sin 100° = Sin (180°—100°) = Sin 80° = Cos 10° = ·98481.
Cos 100° = —Cos (180°—100°) = —Cos 80° = —Sin 10° = —·17365.
Tan 100° = —Tan (180°—100°) = —Tan 80° = —5·67128.

COURSE OF READING

Before attempting a detailed study of the subject from text-books, it would be advisable for the student to obtain a broad outline of principles free from confusing details. Not only will this be found useful when the more difficult portions of the subject are studied, but it will provide an interest and purpose to such studies. An outline in greater detail will be found in *Scientific Ideas of To-day* by Charles R. Gibson (Seeley & Co.), a book written in non-technical language and dealing with such subjects as magnetism, electricity, ether, energy, constitution of matter, and astro-physics. *Paradoxes of Nature and Science* by W. Hampson gives popular explanations of the scientific basis of phenomena which appear to contradict general experience, and will also appeal to many readers. The student should then continue with *The Progress of Physics* by A. Schuster, which consists of but four lectures, *Matter and Energy* by F. Soddy (Home University Library), and *The New Physics and its Evolution* by L. Poincaré (a translation). These last three books the student will no doubt desire to read again in the light of more exact knowledge, to be obtained either from a study of physics from text-books, or from the wider course of reading outlined below.

Most of the text-books published, and their number is very great, only deal with one branch of the subject. The reader who desires a comprehensive treatment of the subject in one book will, however, find it in any one of the following: *A Text-Book of Physics*, by W. Watson (Longmans & Co.), *Intermediate Physics* by the same author, *Ganot's Physics* (Longmans & Co.), or *A College Text-Book of Physics*. Together with one of these, some book dealing with the practical side of the subject should be used to which references as to experimental methods can be made. *Physical Determinations* by W. R. Kelsey (Arnold), or *Experiments in Practical Physics* by Schuster and Lees (Cam. University Press), or *Physical Measurements* by Duff and Ewell (Churchill), or *A Text-Book of Practical Physics* by W. Watson, will be found suitable for the purpose.

The student desiring text-books dealing with only one branch of the subject in greater detail could use any of the following: *Properties of Matter* by Wagstaff (University Tutorial Press), or *Properties of Matter* by Poynting and Thomson (Griffin and Co.), *Heat* by E. Edser (Macmillan & Co.,) or *Heat* by Poynting and Thomson, *Light for Students* by E. Edser (Macmillan), together with *Elementary Geometrical Optics* by Aldis, *Magnetism and Electricity for Students* by H. E. Hadley (Macmillan), or *Electricity and Magnetism* by Poynting and Thomson, or *Elementary Lessons in Electricity and Magnetism* by Silvanus P. Thompson (Macmillan). *Arithmetic of Magnetism and Electricity* by R. Gunn (Blackie & Son) will be found a useful companion book to any of these books on magnetism and electricity. All these books will need very careful reading and study. A not inconsiderable advantage may be obtained by using the whole course of Poynting and Thomson, merely referring to the others for difficult points.

The process of mastering a subject is always facilitated by having the same problems presented in various ways and from different points of view. For this purpose the use of more than one text-book is not advisable, as such books are necessarily very similar to each other both in matter and treatment. The following course, read in conjunction with the text-books selected, will be found far more interesting and instructive. It will be found equally interesting and useful to the reader who cannot devote the time necessary for a close study of text-books.

On the atomic theory—read *The New Knowledge* by R. K. Duncan, a popular book written in a most interesting manner; *Popular Lectures and Addresses* by Sir W. Thomson (Lord Kelvin) —the lecture on "The Size of Atoms." *Matter and Energy* by F. Soddy, chapters II. and III. *Lectures on some recent Advances in Physical Science* by P. G. Tait—the lecture on "Structure of Matter."

On force—read *Lectures on some recent Advances in Physical Science* by Tait—the lecture on "Force."

On gravitation — an excellent treatment without the use of mathematical terms will be found in the *Story of the Heavens* by Sir Robert S. Ball (Cassel & Co.), chapters V and IX.

On energy—read *Lectures on some recent advances in Physical Science* by Tait—the first six lectures. *Matter and Energy* by Soddy, chapter V.

On capillarity—read *Popular Lectures and Addresses* by Sir W. Thomson—the lecture on "Capillary Attraction."

Heat, a form of Motion, *Sound*, and *Light* are three books by J. Tyndall, and form delightful expositions of these subjects by a brilliant experimenter and lecturer.

On nature of heat—read *Matter and Energy* by F. Soddy, chapter IV. *Lectures on some recent Advances in Physical Science* by Tait—the lectures on the "Transformation of Heat into Work" and "Transformation of Heat into Energy."

Wave theory—the phenomena of radiation, sound, and light can only be fully understood if the wave theory is first mastered. *Waves and Ripples in Water, Air, and Ether* by J. A. Fleming (Soc. Prop. of Chr. Knowledge), consisting of a course of Christmas lectures delivered at the Royal Institution will be found an admirable addition to the text-book presentation of the subject. The lecture on the "Wave Theory of Light" in *Popular Lectures and*

Addresses by Sir W. Thomson might also be read.

Conduction and radiation—read *Lectures on some recent Advances*, &c., by Tait—those on "Conduction," "Radiation, and Absorption." *Popular Lectures and Addresses* by Sir W. Thomson, the lecture on the "Sun's Heat. *Radiation* by P. Phillips (People's Books) published by Messrs. Jack, T. C. & E. C., 6*d.*

The scientific basis of music will be found explained in *Sensations of Tone* by Helmholtz (Longman & Co.).

The Science of Light by P. Phillips (People's Books) deals with the subject in a small compass, is well illustrated and quickly read.

Spectrum analysis—*Lectures on some recent Advances in Physical Science* by P. G. Tait contains a lecture on spectrum analysis. The last half of chapter II., and the whole of chapter XXIII in *The Story of the Heavens* by Sir R. S. Ball, treats the subject in a very interesting manner.

Astronomical telescopes—chapter I. of *The Story of the Heavens* contains a clear non-technical description of these instruments.

Light, Visible and Invisible, a series of lectures by Silvanus P. Thompson, should be read, but as it deals with such subjects as Röntgen rays, radium and its rays, manufacture of light, &c., it should perhaps be deferred until some deeper knowledge of magnetism and electricity has been obtained.

A descriptive treatment of magnetism and electricity will be found in two volumes by Charles R. Gibson, viz.: *Electricity of To-day* and *The Romance of Modern Electricity*. Short, pithy descriptions of modern applications of electricity to everyday use are given in *Applications of Electricity* by Alexander Ogilvie in the People's Books Series, 6*d.*

For the theory of the constitution of matter and the electron theory, *The Discharge of Electricity through Gases*, *Electricity and Matter*, and *The Corpuscular Theory of Matter* should be consulted. All three books are by J. J. Thomson.

The Recent Development of Physical Science by W. C. D. Whetham (John Murray) should next be read—it will serve to summarise the course of reading just outlined.

Heroes of Science by Charles R. Gibson is biographical, and will no doubt appeal to many readers.

The student who is interested in scientific "method" and epistemology (the theory of the process by which we know anything at all) will find the subject treated fairly exhaustively in the following books: *Introduction to Science* by J. A. Thomson, *Principles of Science* by W. S. Jevons (Macmillan), *Scientific Method* by F. W. Westaway, *Science and Hypothesis* by H. Poincaré (a translation of this is published by the Walter Scott Publishing Co.), and *The Grammar of Science* by Karl Pearson.

The serious student of physics will find it essential to acquire some knowledge of mathematical terms and methods, and should certainly undertake a course of reading in mathematics if he does not already possess that knowledge. This should include algebra, Euclid, trigonometry, and calculus; some knowledge of analytical geometry is also desirable.

In algebra he should read *Elementary Algebra* by Hall and Knight (Macmillan). The whole of this book, including the section on graphs, should be thoroughly mastered. The reader who wishes to study the subject further could then continue with the *Advanced Algebra* by the same authors.

In Euclid at least Books I to VI should be read. There are numerous editions of Euclid, any one of which will do for the purpose. The one compiled by Hall and Stevens and published by Macmillan & Co. is clearly printed and well arranged.

Trigonometry by Loney (Cam. Univ. Press) is published in two parts. Part I. would be sufficient. *Elementary Trigonometry* by J. B. Lock (Macmillan & Co.) would do equally well, but the whole of this should be mastered.

Calculus is a subject which, unfortunately, is usually presented in a form difficult for beginners to follow. The reader would, therefore, do well first to read *Calculus made Easy* (published by Macmillan & Co.), an excellent little book, which will help to clear the ground. The subject could then be continued in any of the numerous text-books now published. Of these *Differential Calculus* for beginners and *Integral Calculus* for beginners, both by J. Edwards, and published by Macmillan & Co., are as suitable as any. In these the student who is reading calculus with a view to its immediate application to physics might omit chapters V., IX., XI. XII., and XV. in the Differential Calculus, and chapters VIII., latter half of X. and XVII. in the Integral Calculus.

For analytical geometry either *Conic Sections* by C. Smith (Macmillan) or *Co-ordinate Geometry* by Loney (Macmillan & Co.) should be read. The last four chapters in the former and the last two in the latter book might be omitted.

See also section on Mathematics, p. 542.

M. ZAKTRAGER, B.Sc. (Lond.).

CHEMISTRY

HISTORY

It is impossible to trace the history of chemistry right back to its origin, as it has gradually evolved from magic and other of the occult arts. However, it appears that the starting-place of the science was Egypt, which belief is confirmed by the fact that the ancient name for Egypt was Chemia. This name was given in allusion to its black soil, and hence the significance of chemistry as being dark and mysterious in character. The real nature of this art was the production of the noble metals, to which the term alchemy was applied.

The ancient Greeks were also philosophers, and according to the doctrine of Aristotle believed in four "elements"—earth, air, fire, and water. It was considered that all matter was composed of these constituents in varying proportions.

Arabia, also, had its share in the building up of chemistry. The prevalent idea there was that there existed somewhere on the earth the philosopher's stone which would be a panacea for all ills, and would transmute baser metals into gold. Further, it was believed that this philosopher's stone could be made, were the right ingredients mixed in the right proportion. Thus a connection between science and medicine was made, and the application of chemistry to healing became the science for about two centuries. Up to the seventeenth century we find that this state of things existed, and during this time a great advance was made by Paracelsus, the celebrated peripatetic philosopher, who lived 1493–1541.

It was not until Van Helmont (1577–1644) began his work that the old idea of the "elements" was refuted, and chemistry was put upon a much sounder basis. The real foundation of modern chemistry, however, was laid by Robert Boyle (1627–1691), who first conceived a true idea of elements.

Elements, as defined by him, were the simplest forms of matter which could not be broken up into anything further. Compounds were combinations of the elements in various proportions. He imagined that all matter was made up of very small particles. His name is also famous for his work on the relationship between the volume and pressure of gases. Lastly, he held the view that chemistry should be studied for its own sake, and for the advancement of science.

Phlogiston.—It was towards the end of the seventeenth century when the theory of phlogiston was propounded.

Becher who founded, and Stahl who extended, the theory were two German chemists of repute. Their view was that all combustible matter was made up of two constituents—*i.e.* compounds which always contained the substance phlogiston. When a substance burned, it lost its phlogiston, and thus became non-combustible. Thus, in spite of the fact that metals increased in weight when burned, yet it was considered that phlogiston was given off. The metallic calx or earthy residue obtained by burning a metal hence contained no phlogiston whatever. Readily inflammable bodies like coal, wood, &c., were nearly pure phlogiston. For nearly one hundred years did this theory dominate chemistry, and although much progress was made, yet things were kept back through this wrong conception.

The work of three English chemists at this time must be mentioned as showing a very great advance in quantitative work—*i.e.* experiments which involved definite quantities of the substances taken, and the products obtained. Priestley, the discoverer of oxygen, did very valuable work also on other gases, such as laughing gas (nitrous oxide), carbonic oxide, hydrochloric acid gas, &c. Cavendish did great service in showing the constitution of air and water—the latter he showed conclusively to be formed by the combination of two volumes of hydrogen (inflammable air) and one volume of oxygen (dephlogisticated air). Black was the scientist who first showed the existence of carbonic acid gas (fixed air), from his experiments on the alkalis. It was the work of Black which caused the final overthrow of the phlogiston theory, although it was the French chemist Lavoisier who established a correct notion of combustion. Both Priestley and Cavendish, as well as other eminent scientists, clung to the doomed phlogiston to the very end. Lavoisier showed that combustion was merely the combination of the combustible substance with the oxygen in the air. Hence increase in weight was the consequence, as was seen in the fact that the metallic calces were heavier than the metals. Not the least important of the other work of Lavoisier was an explanation of respiration, which he showed to be a form of combustion —oxygen being taken into the body and exhaled

as a compound of oxygen and carbon—fixed air, *i.e.* carbonic acid gas.

The Atomic Theory.—The theory of atoms as propounded by John Dalton at the beginning of the nineteenth century takes an equal place of honour with the theories of Lavoisier.

We often come across the familiar phrase "shivered to atoms," by which we mean that a certain article has been broken into hundreds and thousands of tiny fragments. That all matter was made up similarly of minute particles, had long been the prevalent notion before Dalton's time. But here the idea stopped; nothing more definite about these particles could be imagined. Dalton, however, propounded that all substances could be split up into ultimate particles, which he termed atoms—*i.e.* they could not be further subdivided. Here, however, came the important consideration,—the atoms of different bodies possessed different weights. Thus the atom of oxygen was of a different weight from the atom of hydrogen. The values of the weights of these various atoms he determined by finding the combining weights of the different substances one with another. Now the methods of analysis at this time were rough, and Dalton's figures were inaccurate. Further, the combining weights which he found were not always the atomic weights—*i.e.* the relative weights of the atoms. Hydrogen gas, being the lightest substance known, was taken as the standard—the weight of an atom of hydrogen being one. Now an oxygen atom is found to be 16 times as heavy, a sulphur atom 32 times, and a silver atom 108 times; these numbers therefore represent the atomic weights of these elements. The atomic theory laid down by Dalton was destined to become the framework of modern chemistry.

Dalton's principles of chemical combination depended upon weights. Gay Lussac did much work at this time upon gases and their combination which depended upon volumes. He found that definite volumes of gases combined to form certain compounds. Now much confusion existed because Dalton did not distinguish between atoms of elements, which were quite indivisible, and the ultimate particles of compounds, which were really made up of a combination of atoms of elements. Avogadro, an Italian chemist, first comprehended this distinction, and called such ultimate particles of compounds molecules. But elements themselves might also be divided into molecules—*i.e.* into particles which would possess and exhibit all the particular properties which a mass of the substance did. Thus molecules of elements and compounds retained the characteristic properties of the element or the compound. This molecule could still be split up further when a chemical reaction occurred, and a new substance was produced. When this occurred, it was the atoms themselves which interacted and underwent rearrangement, a chemical change being the result. For example, Dalton found that iron and sulphur when heated will combine to form two different substances according to the proportions taken. Thus the first compound, a black substance called ferrous sulphide, is formed when 1·74 parts of iron and 1 part of sulphur by weight are taken. If 1·74 parts of iron and 2 parts of sulphur are heated together, we get a brass-like body known as iron pyrites. The same amount of iron will combine with different amounts of sulphur in the ratio of 1 to 2—*i.e.* in the ratio of whole numbers. This is an example of a general law without any exception, that the amounts of one element which unite with a fixed weight of another element do so in the ratio of whole numbers.

Indivisible Atoms.—It was this fact which suggested to Dalton the idea of the indivisible atoms. He showed that 1 part by weight of hydrogen combined with 8 parts of oxygen to form water. But the atomic weight of oxygen was not 8, because Avogadro showed that water contains 2 atoms of hydrogen. Hence an atom of oxygen is 16 times as heavy as an atom of hydrogen. The molecule of hydrogen thus contains 2 atoms. The molecule of water contains 3 atoms—2 of hydrogen and 1 of oxygen. A drop of water may be divided ultimately into a certain number of particles, all possessing exactly the same properties. Further division, however, can only result in splitting up these molecules into their constituent atoms—2 of hydrogen and 1 of oxygen.

A clear conception of molecules and atoms is necessary in order to fully understand chemical changes. Many years elapsed before this knowledge was properly comprehended by chemists of last century. Even Berzelius, one of the foremost scientists of his time, wandered very far from the truth, although the values obtained by him for atomic and combining weights remain unto this day.

As the number of elements increased by discoveries of chemists, it was found that many of these elements behaved very similarly to one another. Thus the metals sodium and potassium isolated by Davy had to be kept under naphtha, as on exposure to air they tarnished and quickly changed into oxides owing to their combining with oxygen. They were quickly decomposed with water, much heat being given out in the process. Again, the substances known as chlorine, bromine, and iodine possessed very similar properties. In 1845 Newlands found that if the elements were written in order of their atomic weights, increasing from left to right, at every eighth element resemblance to the first in chemical properties was shown. We know now that Newlands was on the verge of discovering the great "Periodic Law," worked out shortly after by the Russian Professor

Mendeléeff and the German Professor Lothar Meyer. The arrangement of the elements in the order of their atomic weights gave us a table in which progressive properties were seen in the horizontal lines, while the elements in the vertical groups resembled one another. Now this table, known as the Periodic System, had many gaps in it. Even at the present day there are many vacant spaces to be filled by hitherto unknown elements. It was possible, however, to foretell the properties of many new elements, which have since been discovered.

Earth, Air, and Water.—These three substances, together with fire, constituted the four "elements" so called of the ancient Greek philosophers. Every substance was made up of these elements in varying proportions. We can understand how men would first look for an explanation of the composition of substances in the common things which surrounded them. In the same way it will be advantageous for us to approach our subject proper by considering the things with which we are all well familiar.

Earth.—By this term we mean that part of the earth's crust which is accessible. This is composed of very many different substances, the chief of which are silicon and oxygen. Iron, also, has a very fair share in the composition of the earth's crust. Iron is a metallic body known as an element, because we can extract nothing from it that is not iron. Similarly with gold, silver, tin, lead, and other metals, all of which are simple substances which can be decomposed into nothing simpler. Now silicon, although not a metal, is an element, and exists in combination with other elements to the extent of one quarter of the earth's crust.

This combination is chiefly with oxygen, a gas familiar to all, and the compound is known as silica, represented chemically as SiO_2, Si standing for 1 atom of the element silicon, and O_2 as 2 atoms of oxygen. Strange as it may appear, this substance is well known to everyone. Sand, flint, quartz, rock crystal, opal, amethyst, topaz, are all different forms of this one compound. The millions upon millions of tons of sand have been formed from the rocks by the wearing action of wind and wave—this friction rendering the particles spherical like miniature pebbles.

The crust of the earth, which is less than 100 miles in thickness, is composed of about 80 elements. Below this crust is a stratum of molten white hot rock of 160 miles' thickness. Further still, where the heat is intense and the pressure enormous, we still have the rock, but now in the form of a gas. Lastly, we have the core of the earth, 6000 miles in diameter, composed of iron—iron in a gaseous form, again due to the tremendous heat and pressure. All these facts are based upon geological and astronomical evidence, the discussion of which is outside the sphere of chemistry.

It has been shown that iron is an important constituent of the earth's crust. If metallic iron is left for a short time in moist air, a transformation takes place and a reddish-brown substance known as iron rust is formed. Now much of the iron found in nature is in the form of combination with oxygen, and often with other elements as well. Compounds of this nature—silica and iron rust—are known as oxides. Many metals are found in the form of oxides, and also form more complex compounds with silica, carbon, oxygen, &c. Thus the very abundant substance limestone or chalk is a compound of the metal calcium with carbon and oxygen.

Chemical Change.—The common operation known as lime-burning may be considered as a simple example of chemical change. Limestone is strongly heated in a brick furnace known as a lime-kiln. During this process a heavy gas is produced which causes suffocation very quickly. This is carbonic acid gas, or, properly speaking, carbon dioxide, and is simply a combination of carbon and oxygen in the atomic proportions of 1 to 2, indicated by CO_2. It is found that when limestone is thus heated strongly, it loses weight and itself is converted into a white body known as quicklime, which is very different in properties from the chalk. 100 parts of limestone give 56 parts quicklime and 44 parts of carbonic acid gas. Thus from one substance—limestone—we have obtained two different bodies—quicklime and carbon dioxide. This is an example of a chemical change brought about by heat.

If now we beat a lump of quicklime with water—about $\frac{1}{3}$ its weight—the mass swells up, then crumbles, and becomes so hot that part of the water is converted into steam. A powder is left which is slaked lime. This chemical change which has been brought about by means of water can be seen practically any day where building operations are in progress.

quicklime + water = slaked lime.

We generally write chemical changes in the form of an equation. In the case of the limestone, this one substance on heating gave us two products. This is represented in the equation

limestone = quicklime + carbonic acid

or calcium carbonate = calcium oxide + carbon dioxide

where we substitute the chemical names for the common ones of these bodies. The + sign on the right-hand side of the equation signifies simply that different products are obtained. This type of chemical action is known as *chemical decomposition.*

The second type of reaction represented by

quicklime + water = slaked lime

or calcium oxide + water = calcium hydroxide.

Here the + sign on the left-hand side indicates that the substances are added one to the other to give the product on the other side. Obviously this kind of action is just the reverse of the first, and is known as *chemical combination.*

These two examples are types of the most important chemical actions which we shall deal with in Chemistry, and most chemical changes can be placed in one or other of these categories.

Definite Weights.—We have discussed the action of heat upon limestone and the decomposition of the latter into calcium oxide and carbon dioxide. If now we take marble and heat this we find that exactly the same decomposition occurs. Similarly with chalk, which is merely a softer form of limestone. These three compounds—marble, limestone, and chalk—although different in appearance and physical properties, behave exactly in the same manner when heated. This is because they are merely different forms of the same chemical compound, calcium carbonate. Now provided that we deal with the pure substances, it is found that 100 parts of any of these three bodies give 56 parts of calcium oxide and 44 of carbon dioxide. No matter if we obtain specimens from the most remote parts of the earth yet they all decompose on heating in precisely the same proportion. The only conclusion which we can come to is that they are all *composed* of the same elements in exactly the same proportion.

Thus we can always tell what quantities of calcium oxide and carbon dioxide will be produced from a given quantity of marble, chalk, or limestone, providing that the specimens are pure, and that the burning is complete.

In the same way, too, with quicklime, slaked lime, and silica. These compounds are always made up of the same elements in exactly the same proportions.

Elements, Compounds, Mixtures.—It has been stated that up to the present time about 80 substances have been discovered which cannot be broken up into anything simpler, and to these bodies the term element has been applied. Calcium carbonate—as seen in marble, limestone, &c. —has been quoted as a compound, because on heating it will decompose into simpler compounds—calcium oxide and carbon dioxide. Calcium carbonate is an example of a simple compound of three elements—calcium, carbon, and oxygen. Compounds also exist, however, of a very complex nature, made up of a combination of many elements.

The fact that compounds always have exactly the same composition as shown above, distinguishes them from mixtures which may be made up of elements in any proportions. Such a mixture is obtained by grinding up intimately iron filings and powdered sulphur. A uniform greyish substance is produced, but the iron and sulphur can be seen by means of a microscope to be side by side. Further, the iron may be extracted by a magnet. Only two definite compounds of iron and sulphur can be obtained—this by heating firstly 1·74 parts of iron and 1 part of sulphur, the resulting product being a black body. Secondly, 1·74 parts of iron and 2 parts of sulphur will give us a brass-like substance. With either of these compounds it is a difficult matter to obtain the iron and the sulphur separately, and we can only decompose these compounds by chemical means.

Symbols.—We have already seen that we have with some substances used a kind of shorthand notation SiO_2, CO_2, &c. Now each of the elements has a definite symbol which distinguishes it from the others. Thus oxygen is represented by O, hydrogen by H, nitrogen by N, sulphur by S, carbon by C. In these instances the first letter of the name is taken. Often, however, the first letter of the Latin name is used with a subsequent letter also. Aluminium, Al; barium, Ba; calcium, Ca; copper, Cu (cuprum); iron, Fe (ferrum); sodium, Na (natrium); potassium, K (kalium); tin, Sn (stannum); zinc, Zn (zincum).

Now it has been shown that Dalton assigned various weights to the atoms of the elements. To-day when we write the symbol of an element, we mean that a certain weight of that element is to be considered. Hydrogen H is taken as the standard where H means 1 part by weight. Oxygen O signifies 16 parts by weight; sulphur, S, 32; iron, Fe, 56, and so on. In compounds, therefore, such as water, H_2O, we have 2 parts of H and 16 parts of O making a total of 18 parts, which is therefore the weight of a molecule of water, *i.e.* the molecular weight. Similarly quicklime is represented by CaO. Now the relative weight of a calcium atom is 40; that of oxygen 16. Hence $(40+16)=56$ is the molecular weight of CaO or calcium oxide.

Air.—The limit in height of the air which surrounds us is uncertain; it may be 250 miles or it may be more. We do know, however, as a common experience, that the higher we ascend the rarer does the atmosphere become. This is simply because air is matter, and as such has weight, and in consequence the pressure of the atmosphere is greatest at the bottom of the layer. The air forms a protective covering for the earth in more than one sense. Firstly, the heat which is radiated from the sun would be quickly dispelled were it not for the blanket of air which surrounds the earth. The cold would be so intense that apart from other considerations no life could exist at all. Again, the meteors which we often see flashing through the sky would collide with the earth were there no atmosphere. As a matter of fact, the friction of these bodies through the air is so enormous that they are simply burned away long before they approach the earth within striking distance.

Air is always regarded by us as a typical gas, although of recent years it has been found possible to reduce air to liquid, and even solid forms. As such, it is a clear, sparkling liquid, but so intensely cold that ordinary vessels are not able to contain it—it simply boils away at the ordinary temperature. We have to preserve it in vessels invented by Dewar, which are double-walled, with a vacuum between. The popular "Thermos" flask is a common example of this type of vessel.

When preserved in these vessels there is always a mist hovering over the surface, due to the condensation of the moisture in the atmosphere. Most substances change their form when placed in liquid air—due, of course, to the great cold.

Thus liquid mercury becomes instantly transformed to a hard solid which may be used as a hammer. A piece of rubber-tubing dipped for a few seconds into liquid air can be split into fragments by a blow, like a piece of brittle pottery.

The hand may safely be dipped into liquid air (provided that it is withdrawn instantly), because actual contact with the liquid is prevented by the formation of a cushion of air all around the hand. Immersion for a longer period, however, will produce the same terrible results as if the hand were plunged into white, hot, molten iron. Many other peculiar effects can be obtained by the use of liquid air which, unfortunately, cannot be further detailed here.

Constituents of the Air.—Oxygen.—The most important part of the air for living beings is the oxygen. Unless this valuable gas were present in the atmosphere which surrounds us, respiration would be impossible. At the same time, it would not do to have nothing but pure oxygen to breathe. In a very short time our bodies would be consumed by the rapid combustion of our tissues. For actual combustion does take place in our bodies, and the heat of the body is the result of this burning. When we breathe air into our lungs, the oxygen comes into contact with the blood, and is there absorbed by it. This is because the red corpuscles contain a substance known as hæmoglobin, and this combines with the oxygen to form oxyhæmoglobin. Thus

Hæmoglobin + oxygen = oxyhæmoglobin.

This oxyhæmoglobin is circulated through every part of the body by means of the arteries, and is the bright red colour of arterial blood.

Throughout its journeyings it comes into contact with waste tissue containing much carbon, with the result that after a series of changes, this carbon unites with the oxygen to form carbonic acid gas or carbon dioxide. Thus the oxyhæmoglobin is reconverted into hæmoglobin, and the carbon into carbon dioxide.

Carbon + oxygen = carbon dioxide.

This hæmoglobin is carried back through the veins to the lungs where it loses its carbon dioxide, and the hæmoglobin again takes up oxygen.

Now when a piece of charcoal is burnt heat is given out—due to the combination of the oxygen with the carbon of the charcoal to form carbon dioxide. Similarly the combination in the body is accompanied by heat, and the warmth of the body is due to the production of carbon dioxide.

Hence we see that the greater the amount of oxygen absorbed, the greater will be the heat produced. Thus, in order to prevent too quick combustion in our bodies the air is diluted with a gas which does not change in any way in the lungs. This is nitrogen, and, roughly speaking, our air consists of 4 parts of nitrogen to 1 part of oxygen.

That this is so can be easily demonstrated by burning a piece of phosphorus in a closed vessel standing in a trough of water (the open end being under water). After burning for a short time, during which white fumes are formed, the phosphorus ceases to burn, the white fumes dissolve in the water, and the latter has been found to have risen to about one-fifth the height of the vessel. The phosphorus has combined with the oxygen in the air, thus

phosphorus + oxygen = phosphorus oxide

using up 1 part of oxygen and leaving 4 parts of nitrogen.

Oxygen in appearance cannot be distinguished from air—an invisible, odourless gas. Pure oxygen, when viewed in very large quantities, appears blue. The difference between oxygen and air, however, is seen when different substances are allowed to burn in it. Sulphur burns feebly in air with a pale blue flame; in oxygen it burns with an intense lilac flame producing the suffocating gas—sulphur fumes—which is chemically known as sulphur dioxide.

Again, iron will not burn in air; in oxygen, a piece of iron heated previously will burn vigorously, emitting very brilliant sparks in all directions like a firework.

Similarly, many substances will burn with dazzling brilliancy in oxygen, and in each case a product of that substance combined with oxygen will be the result. Such compounds are termed oxides—we have already come across some of them such as silicon dioxide or silica, SiO_2, and carbon dioxide, CO_2.

Oxygen can be obtained from many bodies which are combined with it. Such bodies as the oxides of mercury, lead, barium, when heated decompose evolving oxygen. Chlorate of potash, or potassium chlorate, is a very convenient

method for obtaining a supply for experimental purposes. A better yield is obtained by mixing it with a small quantity of the mineral pyrolusite or oxide of manganese. When this mixture is heated in a retort, the oxygen can be collected in jars over water by means of a delivery tube. At the present day oxygen is produced in large quantities from liquid air. This being a mixture of nitrogen and oxygen, the nitrogen is allowed to boil off first, thus leaving pure oxygen behind. This liquid oxygen is strongly magnetic, *i.e.* it is attracted to the poles of a magnet just like iron.

From the humanitarian point of view chemistry has been of the greatest service to man in showing how oxygen may be easily and cheaply produced. We have only to think of the great use made of compressed oxygen for divers, rescuers in coal mines, &c., and also of its use in medicine in cases of extreme weakness and enfeeblement, to realise what an invaluable boon oxygen is to mankind.

Mention must be made here to another form of oxygen also found to a very small extent in the atmosphere. This is known as ozone, and is the cause of the peculiar smell always detected in the neighbourhood of an electrical machine. It occurs in fairly large quantities at many of the London underground electric stations. Ozone is a gas which can be obtained from oxygen by electrical means, and is even more active than oxygen in its chemical behaviour. The salubrity of seaside air is sometimes attributed to the ozone present.

Nitrogen.—We noticed that when phosphorus was burnt in air contained in a closed vessel that about one-fifth of the air combined with the phosphorus, this being the amount of oxygen in the air.

A gas is left which will not combine with most substances at all, being a chemically inert gas. When we breathe, the nitrogen is not at all changed in our lungs, although present in quantities four times as great as the oxygen. A taper is immediately extinguished when plunged into nitrogen, and very few metals when heated with it will combine. Magnesium—that metal used by photographers in the form of ribbon for flashlight photographs—if heated strongly will combine with nitrogen to form magnesium nitride Mg_3N_2.

Now, in spite of the fact that the vast quantity of nitrogen in the air seems to be of no use on account of its inactivity, yet it plays a most important part in the economy of life. Many plants are capable of assimilating small amounts of free nitrogen, but the quantities are much too small to sustain their life. Nitrogen is absolutely necessary to the vegetable world, but it must be in such a form as to be easily assimilated. It must be "fixed"—*i.e.* combined with some other element or elements to form compounds which can be absorbed by plant life. It is in this so-called "fixed" form that the nitrogen is present in the artificial manures and fertilisers. The most well-known of these is the "nitrate of soda," or Chili saltpetre, which has the formula $NaNO_3$. This is a substance which is found in huge deposits in Chili—but how has it come there? Bacteriology comes to our aid in answering this question, and we find that there are certain organisms which are capable of absorbing "free" nitrogen, and "fixing" it in such a way that when these organisms die, the nitrogen is found as the salt sodium nitrate. Naturally this process is going on all over the earth, but the nitrates are dispersed by rain, and thus in the ordinary way no very great accumulation occurs. The particular strip of country in Chili, however, has for numberless centuries been rainless, and so the nitrate has been collecting in increasing quantities.

A second way in which nitrogen is fixed in nature is by its chemical combination with oxygen, which occurs at very high temperatures. Now every flash of lightning causes combination of the nitrogen and the oxygen in the air, with the formation of so-called oxides of nitrogen, chief of which is NO_2. These oxides dissolve in water to form nitrous and nitric acids, and hence during thunderstorms, relatively large quantities of these acids are washed down to the earth.

Sir William Crookes, in 1892, showed that combination could be easily effected between nitrogen and oxygen by means of electric sparks. This is exactly the same reaction as goes on in the atmosphere when the lightning flashes. This principle is the foundation of the artificial production of sodium nitrate. Imagine the carbon arcs in an arc lamp replaced by tubes of copper in which circulates a very rapid stream of water to keep them cold. A very powerful arc is struck between these electrodes and is caused to spread out in the shape of a disc of flame by means of an electro-magnet. Air is forced through this white-hot disc of flame at the rate of 3000 feet per minute, with the result that the oxide of nitrogen is produced, known as nitric oxide, NO. This immediately takes up more oxygen from the air to form NO_2. $NO + O = NO_2$. This gas is passed up water towers where it meets a stream of dilute caustic soda or milk of lime. In this way a mixture of either sodium nitrite, $NaNO_2$, and sodium nitrate, $NaNO_3$, is formed, or else calcium nitrite, $Ca(NO_2)_2$, and calcium nitrate, $Ca(NO_3)_2$. In any case, the mixtures can be successfully employed directly on to the soil. This process is carried on in Norway, where advantage can be taken of the water-power to generate the necessary supply of electricity. Naturally, the full advantage of this manufacture will be seen when the natural deposits of nitrates are exhausted, which will not be very many years hence at the present rate of consumption.

Nitrogen, besides its immense importance to plant and human life, also plays a valuable part in other directions. Many of our dyes contain nitrogen as an essential part of their constitution. The majority of our most useful drugs and medicines, as well as nearly all our explosives, have nitrogen as the parent substance.

The question now arises, if so much nitrogen is being used from the atmosphere, how is it that the supply does not diminish? Nitrogen is being constantly given back to the atmosphere owing to plant and animal decomposition. Wherever decay occurs, we find that compounds of nitrogen—chiefly ammonia—are evolved which find their way back to the air. Thus a balance is maintained between the consumption and production of the nitrogen by natural means.

Rare Gases.—Lord Rayleigh, in 1894, discovered that a litre of nitrogen prepared from the air weighed heavier than a litre prepared from the compounds of nitrogen. This he found was due to the presence of another gas heavier than nitrogen. Experiments were conducted in conjunction with Sir William Ramsay, and they isolated this gas and found that it was much more inactive even than nitrogen—in fact, it would not combine with any element. They named the gas argon (from the Greek, meaning "without work"), and beyond the fact that it can be liquefied at a low temperature, little is known about it. It is colourless and odourless, and exists in the air to the extent of 6 parts in 1000.

Later work showed that other gases very similar to argon in inertness, existed in the atmosphere—such as krypton, xenon, and neon. These gases are present in exceedingly small quantities, a mixture of them only occurring to the amount of 25 parts in every 1,000,000 parts of argon present.

Carbon Dioxide.—This gas has already been noticed as one of the products obtained by heating limestone. Black, who discovered this gas, termed it "fixed air" because he regarded it as being held by the limestone.

$$\underset{\text{Calcium carbonate}}{CaCo_3} = \underset{\text{Calcium oxide}}{CaO} + \underset{\text{Carbon dioxide}}{CO_2}$$

The amount of carbon dioxide in the air is very small, about 3 parts in 10,000 in the country air. In towns, however, there is an increase to about 4 or 5 parts in 10,000, due to the oxidation of the carbon to carbon dioxide. This is brought about by the consumption of carbon (coal, coke, &c.) as fuel, and by the respiration of human beings. We have already discussed this action, and have seen that

$$\underset{\text{Carbon}}{C} + \underset{\text{Oxygen}}{O_2} = \underset{\text{Carbon dioxide}}{CO_2}$$

represents the chemical change.

Although the carbon dioxide is present in such small quantities, yet it has a great bearing upon the conditions of life generally. Thus plants are able to absorb the gas. The active agent in this absorption is the green colouring matter of all vegetable life, known as chlorophyll. This substance is capable of abstracting carbon dioxide from the air, decomposing it into carbon and oxygen, retaining the former in the plant, and expelling the latter. Naturally this reaction is the reverse of the above, and as such is shown by

$$\underset{\text{Carbon dioxide}}{CO_2} = \underset{\text{Carbon}}{C} + \underset{\text{Oxygen}}{O_2}$$

Hence, there is a balance between the carbon dioxide set free and the amount reconverted into oxygen by the plant economy.

Then again, the carbon dioxide existing in the air is dissolved by the rain which descends, giving an acid known as carbonic acid (whence the original name of the gas—carbonic acid gas). This acid, although very weak and dilute, acts upon certain kinds of soil, chiefly limestone, causing it to dissolve. The explanation of the "wearing action of the weather" is due principally to this fact. The abundance of caves, often of huge extent, found in the regions of chalky soils, is the result of this wearing away.

Carbon dioxide is a colourless gas; it is said also to be odourless and without taste. Yet everyone is familiar with that tingling sensation in the nose and throat produced by soda water and other mineral waters. The refreshing quality of such beverages is due to this carbon dioxide, which is forced in under pressure, and hence, when the pressure is released by opening the stopper of the bottle, the gas escapes.

If a taper is plunged into a jar of carbon dioxide it is immediately extinguished. That is, like nitrogen, it will not support combustion. Advantage is taken of this fact in the manufacture of the "fire extinguishers." The gas is either stored or generated under pressure, and by directing the stream of gas on to the conflagration the flames are extinguished.

It will be understood, therefore, that respiration will be impossible in an atmosphere of carbon dioxide, the venous blood not being able to part with the absorbed gas. Hence the fatalities due to breathing the gases in disused mines and wells, the fumes from lime-kilns and brewers' vats. The terrible choke-damp in coal mines is due to the formation of carbon dioxide during the explosion, and often miners who have survived this latter, succumb to the deadly vapour. In many parts of the world, too, large quantities of the gas are found issuing from the soil. Generally these spots are, or have been, volcanic, the tremendous heat having decomposed the limestone and other carbonates. The "Death Gulch" of Western America, the "Valley of Death" of Java, and the cave near Naples known as the "Grotto del Cano" are especially famous. In this latter place it is found that human beings may walk

about safely, while smaller animals, such as dogs, become suffocated and die. This is because carbon dioxide is a very heavy gas, and always settles to the bottom. Thus it is possible to pour the gas from one vessel into another like a liquid; also soap bubbles will float upon a layer of gas.

Carbon dioxide, although fatal to life, is not a poisonous gas in the usual sense. Otherwise it would not be safe to drink liquids containing the gas. But it is found that the effects of taking the gas into the stomach is more beneficial than otherwise. No, carbon dioxide merely asphyxiates, and does not poison the body. The stuffiness of a crowded room, which induces headache, is partially due to the increased amount of carbon dioxide from the respired breath of the people. The bad effects are due to the poisoning of the system by the bacteria and effluvia exhaled from the peoples' bodies. However, the amount of carbon dioxide present can always be taken as a measure of the purity of the air. Carbon dioxide may be easily obtained in quantity by acting upon limestone, marble, &c., with any acid—even vinegar. All carbonates behave similarly, and the effervescence of Seidlitz powder depends upon this reaction. Such powders are mixtures of bicarbonate of soda and tartaric acid. No reaction can take place in the solid form, however, because we cannot bring the molecules of each close enough into contact. Dissolving in water causes the molecules to collide and split up with the evolution of carbon dioxide.

Similarly, most baking powders are mixtures of this type—the bubbles of gas evolved force their way through the dough, distend it, and thus impart lightness and porosity to the bread or cake.

Water Vapour.—The invisible gas known as water vapour is the last thing to be considered, although by no means is it the least important of the constituents of the atmosphere. For example, the temperature of the earth would be much lower were it not for the water vapour present. The sun sends its light and heat to the earth in the form of luminous rays. The earth reflects the heat rays, but not as luminous rays. Now water vapour is quite transparent to luminous rays, and hence the rays from the sun permeate through. On the other hand, the dark heat rays emitted by the warm earth will not pass through water vapour, and thus are prevented from escaping.

The amount of water vapour present in the air varies considerably. The housewife knows this only too well, on the days when her washing will not dry. Temperature is an important factor, and there is a definite maximum amount of water vapour for each temperature which the air is capable of taking up. When this is the case, the air is said to be saturated, and this happens during fogs and rainstorms. Usually, however, the air only contains about two-thirds of the maximum amount of moisture.

The constitution of water vapour will be fully dealt with under the next heading—Water.

Water.—We have just been considering this very familiar substance in one of its three forms—that of vapour. Perhaps we are better acquainted with it in its liquid state, covering as it does three-quarters of the earth's surface. Then, again, it is the *terra firma* at the poles in the solid form of ice. Water is not restricted to our world alone, however, and astronomical chemistry shows us that it is practically a universal substance, its presence having been proved on many other planets.

Water is a fundamental constituent of all plant and animal life, and this earth would be a mere desolate waste, dreary and lifeless, without it. No wonder the ancients termed it one of the "elements," and, in their meaning of the word, it was not far from the truth.

Evaporation of any water obtained from natural sources will leave a residue, differing in kind and quantity according to the source. Thus sea-water contains many different bodies in solution—the chief being common salt, sodium chloride, $NaCl$. Water obtained from chalky districts will contain limestone—calcium carbonate, $CaCO_3$, while the so-called chalybeate waters contain iron as ferrous carbonate, $FeCO_3$. Many spring waters have varying quantities of gases in solution, such as the sulphurous springs of Harrogate. All the water referred to above also contains dissolved air, which has its special significance in the order of nature. Fish are able to exist by breathing this dissolved air, and much purification is effected in rivers and springs by the oxidation of the impurities.

Now it is evident that we must be able to obtain water free from all these different substances. Pure water may be obtained by converting it into water vapour by heating, and then condensing this back again to water minus the substances in solution. This process, known as distillation, gives us a product with a disagreeable flat taste, due to absence of air in the water. Now water obtained in this way is a colourless liquid when seen in small quantity, possessing in large masses, however, a greenish-blue tint. The conversion of liquid water into solid ice is attended by an increase in volume (roughly $\frac{1}{11}$) so that, bulk for bulk, the ice is lighter than water. Hence ice always floats on the surface, so that lakes and rivers are never frozen right through, which, of course, would be fatal to aquatic life.

Another result of this expansion is the disintegration of the rocks by the increase in pressure of the water, which freezes in the holes and crevices of the soil.

Composition of Water.—It seems inconceivable that water should be composed of two invisible

gases—hydrogen and oxygen—yet analysis shows us that water is nothing more or less than a chemical combination of hydrogen and oxygen in the proportions of 2 volumes to 1.

Thus if we pass an electric current through water slightly acidulated (to conduct electricity) we shall be able to collect hydrogen from one electrode (cathode) and oxygen from the other (anode), and there will be twice as much hydrogen as oxygen. Similarly we can perform a synthesis (*i.e.* a building up) of water by passing an electric spark through a mixture of 2 volumes of hydrogen and 1 volume of oxygen. If we keep the vessel surrounded by steam at 100° C. (212° F.) the water is kept in the state of vapour, and it is found that 3 volumes of the mixed gases have contracted to 2 volumes of water vapour. Now when we compare the weights of equal volumes of steam and of hydrogen, we discover that the steam weighs 9 times as heavy as the hydrogen. But Avogadro showed that equal volumes of all gases contained equal numbers of molecules. Hence 1 molecule of water vapour weighs 9 times heavier than 1 molecule of hydrogen. Further, we know that a molecule of hydrogen contains 2 atoms, and one of these atoms is taken as the standard unit of weight. Thus the molecule of water is $2 \times 9 = 18$ times heavier than an atom of hydrogen. As shown above, the quantitative synthesis of water gives hydrogen and oxygen in the proportion 1 : 8 or 2 : 16. Hence the formula for water must be H_2O.

In a similar way the formula for other gases and vapours may be obtained.

Water is by far the commonest solvent we have. In this connection we have to distinguish between mere solution of a substance in water and definite chemical combination. Thus if we dissolve common salt, NaCl, in water, and then evaporate the water, we obtain the salt in exactly the same condition as before. Any chemical attraction which has taken place is of such a feeble nature that by simply evaporating the water this attraction is broken down, and we are left with the salt in the same amount and character.

On the other hand, water will combine chemically with quicklime, CaO, causing it to crumble up to powder which is a different body known as slaked lime. Chemically this is termed calcium hydroxide or hydrate, and its formula $Ca(OH)_2$.

$$\underset{\text{Calcium oxide}}{CaO} + \underset{\text{Water}}{H_2O} = \underset{\text{Calcium hydroxide}}{Ca(OH)_2}$$

This is an example of a general type of reaction where metallic oxides combine with water to form hydrates or hydroxides.

In the first case, where no chemical action occurred, we often get the water held loosely by the salt as it were, so that we have a solid body at ordinary temperatures which contains a considerable amount of water. Glauber's salt, or sodium sulphate, when dissolved in hot water and allowed to cool, separates out in crystals which have the composition $Na_2SO_4 \cdot 10H_2O$. When heated now to the boiling-point of water (100° C. or 212° F.) it is converted into the body Na_2SO_4, which is termed anhydrous (*i.e.* without water). The water thus held by the salt is known as "water of crystallisation," and in no way alters the chemical properties of the salt. Many substances, such as common salt, NaCl, crystallise without this water of crystallisation.

Coloured crystalline salts which contain water of crystallisation generally change colour when this water is expelled. Thus blue stone or copper sulphate, $CuSO_4 \cdot 5H_2O$, heated at 100° C., loses 4 molecules of water, thus $CuSO_4 \cdot H_2O + 4H_2O$, and becomes colourless. The remaining molecule of water, known as "water of constitution," can be removed by further heating above 100° C.

Sympathetic inks depend upon this principle. The commonest of these is cobalt chloride, $CoCl_2 \cdot 6H_2O$, which is a red crystalline body, dissolving in water to give a pink solution. Characters written with a dilute solution of this substance are practically invisible. On warming the paper, however, the water of crystallisation is expelled, and we get a body $CoCl_2 \cdot H_2O$, which is of a bright blue colour, and hence the writing shows up plainly. On leaving in the air, the anhydrous salt again absorbs moisture from the air to form $CoCl_2 \cdot 6H_2O$, and the writing turns invisible again.

Natural Waters.—We have noted that the rain in passing through the air absorbs carbon dioxide, which allows it to act as a weak acid and to dissolve certain salts—*e.g.* limestone, calcium carbonate. Now calcium carbonate is insoluble in pure water, so that it cannot exist as such in water. The carbon dioxide causes it to form a substance known as calcium hydrogen carbonate, $CaH_2(CO_3)_2$.

$$\underset{\substack{\text{Calcium}\\\text{carbonate}}}{CaCO_3} + \underset{\text{Water}}{H_2O} + \underset{\substack{\text{Carbon}\\\text{dioxide}}}{CO_2} = \underset{\substack{\text{Calcium hydrogen}\\\text{carbonate}}}{CaH_2(CO_3)_2}.$$

If now the CO_2 is expelled from the water, the $CaH_2(CO_3)_2$ reverts to the ordinary $CaCO_3$. Hence the formation of stalactites and stalagmites. Water containing the $CaH_2(CO_3)_2$ drips slowly from the roof of a cavern; the Co_2 evaporates, and the calcium carbonate is left. Thus from the floor of the cave there rises in the course of time a column of calcium carbonate, which is met by a similar formation growing downwards from the roof.

Hard Water.—The carbon dioxide may be expelled by boiling the water, when the calcium carbonate is deposited. The "furring" of kettles, and the formation of boiler crust is a direct result of the liberation of carbon dioxide.

A hard water is one which requires much soap before a lather can be obtained. This is because it contains in solution a fair quantity of salts, such as calcium bicarbonate, $CaH_2(CO_3)_2$, calcium sulphate, $CaSO_4$, and the similar salts of magnesium.

Soap consists of the soluble sodium and potassium salts of organic acids. These interact with the soluble calcium and magnesium salts in the water, to form insoluble salts of these metals. Hence before soap can be used as a detergent, all these insoluble salts must be precipitated, which results in the curdy flakes produced in washing with hard water. Much soap is this wasted, and it is economically preferable to use as soft a water as possible for washing purposes.

Hardness of water is of two kinds—temporary and permanent. Temporary hardness is due to calcium bicarbonate, $Ca(HCO_3)_2$, and is easily removed by boiling, which deposits normal calcium carbonate, $CaCO_3$. Other salts dissolved in the water, such as calcium sulphate, however, are not removed in this way, but can be removed by the addition of sodium carbonate, Na_2CO_3—washing soda. The soluble calcium salts will be precipitated as calcium carbonate, $CaCO_3$. Of course, sodium carbonate will precipitate all calcium salts in this way, and so will remove both temporary and permanent hardness. This method is unsuitable where the water is to be used for drinking purposes, because of the amount of sodium salts left in solution. Further, permanent hardness does not interfere with the drinking quality of the water. The water for ordinary household supply is generally softened by the addition of slaked lime, $Ca(OH)_2$ which removes temporary hardness by precipitating calcium carbonate. This process is known as Clark's Method.

Soft Water.—Although in many respects it is advantageous to use soft water, yet there is the danger due to its action upon lead. Lead pipes are most convenient to use for the transmission of water. Now soft water—*i.e.* water containing but little calcium salts—is capable of dissolving the lead oxide which is formed by the action of the oxygen dissolved in the water. The film which dulls the surface of a bright piece of lead exposed to moist air, or placed under water, is simply oxide of lead, PbO. Hard water which contains calcium salts is not able to dissolve this lead oxide to anything like the extent of soft water. Hence the risk of lead poisoning by using soft water for drinking purposes. However, as all water has some solvent action upon lead, it is desirable that this metal should be avoided as much as possible.

Oxides.—We have frequently referred to this class of body in our study up to the present. The majority of elements, when heated in air or oxygen, burn with the formation of a compound known as an oxide. Thus SiO_2, CO_2, PbO, CuO, may all be prepared by heating the elements silicon, carbon, lead, and copper in air. Many substances will form more than one compound with oxygen. Thus carbon heated in an insufficient air supply will produce a gas known as carbonic oxide or carbon monoxide, CO. The blue flames which play on the top of a clear coal or coke fire are due to the burning of this gas, for, unlike the higher oxide, carbon monoxide is inflammable.

$$\text{(i)}\quad \underset{\text{Carbon}}{C} + \underset{\text{Oxygen}}{O} = \underset{\text{Carbon monoxide}}{CO}$$

The burning of this gas is due to its combining with a second atom of oxygen to form carbon dioxide—$CO + O = CO_2$.

Carbon monoxide is a very poisonous gas, as it combines with the hæmoglobin in the blood to form carbonyl-hæmoglobin, which prevents the formation of oxy-hæmoglobin, and respiration is unable to proceed.

The small amount of 1 per cent in the atmosphere is fatal. There is always a certain amount of this gas in the "afterdamp" in the coal mines following an explosion, and generally this quantity is sufficient to cause death very quickly.

Oxides of Sulphur.—Everyone is familiar with the smell of burning sulphur (brimstone), which is due to the formation of sulphur dioxide, SO_2:

$$\underset{\text{Sulphur}}{S} + \underset{\text{Oxygen}}{O_2} = \underset{\text{Sulphur dioxide}}{SO_2}$$

From the earliest times sulphur has been used as a disinfecting and cleansing agent. Thus in Homer's *Odyssey* we get the words:

> "Quickly, O nurse, bring fire, that I may burn
> Sulphur, the cure of ills"

—referring to the need for cleansing because of the dead bodies of the slain suitors.

Sulphur burns in air with a blue flame, combining with the oxygen of the air to form sulphur dioxide, which is the actual disinfecting agent. The gas is fatal to bacteria of all kinds, and acts as a blood poison upon the animal economy.

Sulphur Trioxide, SO_3.—The action of heat upon green vitriol or ferrous sulphate, $FeSO_4 \cdot 7H_2O$, is to first expel the water, and then to give a fuming gas which is known as sulphur trioxide, SO_3. This will react with water to give us "oil of vitriol" or sulphuric acid, H_2SO_4.

$$\underset{\text{Sulphur trioxide}}{SO_3} + \underset{\text{Water}}{H_2O} = \underset{\text{Sulphuric acid}}{H_2SO_4}$$

Now sulphur dioxide will take up oxygen to form the trioxide only under special conditions, such as heating the mixture of gases in the presence of finely-divided platinum.

$$\underset{\text{Sulphur dioxide}}{SO_2} + \underset{\text{Oxygen}}{O} = \underset{\text{Sulphur trioxide}}{SO_3}$$

Oxides of Nitrogen.—We have already seen that nitrogen and oxygen can be made to com-

bine at a very high temperature to form nitric oxide, NO, and that at ordinary temperatures this gas, which is colourless, will take up more oxygen to form nitrogen peroxide, NO_2.

Now we can obtain other oxides of nitrogen indirectly, and in all, five are known. N_2O—nitrous oxide or laughing gas—is used as an anæsthetic for minor operations; NO, nitric oxide, formed in the fixation of nitrogen; N_2O_3, nitrogen trioxide; NO_2, nitrogen peroxide, and N_2O_5, nitrogen pentoxide.

This latter substance when cooled is a white solid which combines with water with great eagerness to form "aqua fortis" or nitric acid, HNO_3.

Phosphorus also forms the white body in phosphorus pentoxide, P_2O_5, when it burns in air or oxygen. This is also a white solid which reacts violently with water like the quenching of red-hot iron. Phosphoric acid is the chief product of the combination with water. By modifying the conditions of burning the phosphorus we can obtain another oxide of phosphorus, P_4O_6, known as phosphorous oxide.

Practically all the oxides which we have just considered will dissolve in water to give liquids that are acid in character. Amongst other properties, acids have a sour taste, and turn blue litmus (a vegetable colouring matter) red.

The oxides obtained from such non-metals as carbon, sulphur, nitrogen, and phosphorus are termed acidic oxides. Thus carbon dioxide and water will form carbonic acid.

$$\underset{\text{Carbon dioxide}}{CO_2} + \underset{\text{Water}}{H_2O} = \underset{\text{Carbonic acid}}{H_2CO_3}$$

Sulphur dioxide, SO_2, and sulphur trioxide, SO_3, will give sulphurous and sulphuric acids respectively:

$$\underset{\text{Sulphur dioxide}}{SO_2} + \underset{\text{Water}}{H_2O} = \underset{\text{Sulphurous acid}}{H_2SO_3}$$

and

$$\underset{\text{Sulphur trioxide}}{SO_3} + \underset{\text{Water}}{H_2O} = \underset{\text{Sulphuric acid}}{H_2SO_4}$$

Nitrogen pentoxide and water react violently to give nitric acid:

$$\underset{\text{Nitrogen pentoxide}}{N_2O_5} \quad \underset{\text{Water}}{H_2O} \quad \underset{\text{Nitric acid}}{2HNO_3}$$

These examples suffice to show the typical property of the oxides of non-metals.

When we now consider the compounds formed by combination of oxygen with metals, we find that they behave very differently.

Of course the distinction between the metals and non-metals as regards physical properties such as appearance, malleability, ductility, &c., is commonly known. One important chemical difference is the fact that few metals form compounds with hydrogen, whereas nearly all non-metals combine with this element, forming stable compounds.

The combination of metals with oxygen is also different. Not all metals can be made to combine directly—silver, gold, and platinum being typical. All the commoner metals, however, burn in air. Sodium will form Na_2O, zinc ZnO, magnesium MgO, &c. Then, again, many of these oxides are insoluble in water, while practically all non-metallic oxides dissolve, producing acids.

When, however, oxides of the metals Na_2O, CaO do dissolve, they give solutions opposite in character to acids. Red litmus is turned blue and the solutions will "neutralise" acids, *i.e.* destroy their acid properties. For this reason the oxides of the metals are termed basic oxides, and the solutions of such oxides, bases. The word "alkali" is also used in reference to a solution of a very soluble oxide such as sodium oxide.

$$\underset{\text{Sodium oxide}}{Na_2O} + \underset{\text{Water}}{H_2O} \rightarrow \underset{\substack{\text{Sodium hydroxide}\\\text{(Caustic soda)}}}{2NaOH}$$

There is no absolutely definite distinction, however, and any solution capable of turning red litmus blue and of "neutralising" acids is known as "alkaline."

The slaking of lime gives us a body which is sparingly soluble in water, giving an alkaline solution:

$$\underset{\text{Quicklime}}{CaO} + \underset{\text{Water}}{H_2O} = \underset{\text{Slaked lime}}{Ca(OH)_2}$$

Lastly, we have metallic oxides like zinc oxide, ZnO, which are insoluble in water, yet will "neutralise" an acid.

When a base and an acid are brought together in the right proportions, we get a "neutral" solution, *i.e.* one that neither turns litmus red nor blue. From this solution, by evaporating some of the water, and thus concentrating, we can generally obtain a crystalline body, termed a salt.

Thus by adding a solution of sodium hydroxide, NaOH (caustic soda), to hydrochloric acid, HCl, so that the red colour of the litmus is just turned blue, we get formed sodium chloride, NaCl (common salt) in solution, which can be isolated by evaporation.

$$\underset{\substack{\text{Sodium}\\\text{hydroxide}}}{NaOH} + \underset{\substack{\text{Hydrochloric}\\\text{acid}}}{HCl} = \underset{\substack{\text{Sodium}\\\text{chloride}}}{NaCl} + \underset{\text{Water}}{H_2O}$$

The quantities of caustic soda and hydrochloric acid used thus are termed "equivalent." It must just be noticed here that this word is used with a different meaning from that in connection with the "combining" or "equivalent" weight of one element with another.

Now, although most oxides can be placed in one or other of the categories "acidic" or "basic," yet there are some which cannot be assigned to either. Water—hydrogen oxide—H_2O, is of this nature. Another compound known as hydrogen peroxide (or dioxide), H_2O_2, is a similar type of substance. This latter body

is a liquid very much more unstable than water. It readily decomposes into water and oxygen,

$$\underset{\text{Hydrogen peroxide}}{H_2O_2} = \underset{\text{Water}}{H_2O} + \underset{\text{Oxygen}}{O}$$

On this account it is termed an oxidising agent, and is used for bleaching purposes—chiefly with substances which would be injured by the drastic action of bleaching. Thus in dilute solution it is used for bleaching hair yellow (generally ladies'), and for producing white teeth, &c. The restoration of old pictures is another interesting example of its use. In the days gone by, white lead was the compound universally employed by artists for giving "body" to their colours. This white lead, in the course of time, becomes acted upon by small quantities of hydrogen sulphide, H_2S, a gas generally present in minute quantities in the air of towns. The result of this chemical action (which often takes many years to complete) is to form lead sulphide, PbS, which is black, and thus causes the picture to darken considerably, frequently becoming quite black. Now lead sulphide is easily oxidised to the white body lead sulphate:

$$\underset{\text{Lead sulphide}}{PbS} + \underset{\text{Oxygen}}{2O_2} = \underset{\text{Lead sulphate}}{PbSO_4}$$

Thus when a picture, black and discoloured, is washed over with a dilute solution of hydrogen peroxide, the black lead sulphide is removed, and the original colours are restored.

Hydrogen peroxide is sold commercially in solutions such as "10 volume" solution. This simply means that 1 volume of the solution will yield 10 volumes of oxygen. Such a solution contains actually about 3 per cent. of hydrogen peroxide.

Common Acids and Bases.—There are three acids which are largely used both commercially and in the laboratory. They are sulphuric, nitric, and hydrochloric acids. By far the most important is sulphuric acid, H_2SO_4. This is obtained indirectly from sulphur, sulphur dioxide being first formed by heating the sulphur, which is then made to combine with another atom of oxygen to form sulphur trioxide.

$$\underset{\text{Sulphur dioxide}}{SO_2} + \underset{\text{Oxygen}}{O} = \underset{\text{Sulphur trioxide}}{SO_3}$$

This latter body dissolves in water to give us sulphuric acid, $SO_3 + H_2O = H_2SO_4$. The oldest method for bringing about this change on the large scale is known as the "chamber process," and is far more elaborate than the newer "contact process." In this latter, sulphur dioxide and oxygen are simply passed over specially prepared platinum, which causes them to unite and thus produce sulphur trioxide, SO_3.

The crude acid of commerce known as oil of vitriol contains about 20 per cent. of water, as well as other impurities which cause it to be of a brown colour. Its corrosive action is well known; great heat is produced when it is brought into contact with water, hence in diluting it great care must be taken.

Nitric Acid, HNO_3.—This acid is prepared by heating together nitre, KNO_3, or Chili saltpetre, $NaNO_3$, with concentrated sulphuric acid. Nitric acid vapours are formed, which are cooled in a receiver to a brownish fuming liquid.

$$\underset{\text{Sodium nitrate}}{NaNO_3} + \underset{\text{Sulphuric acid}}{H_2SO_4} \quad \underset{\text{Sodium hydrogen sulphate}}{NaHSO_4} + \underset{\text{Nitric acid}}{HNO_3}$$

When pure, nitric acid is a colourless liquid which has a very corrosive action, hence its name, "aqua fortis." Most vegetable and animal substances are stained yellow when attacked by nitric acid.

Hydrochloric Acid, HCl.—The third of the common acids, formerly designated "muriatic acid," differs in several respects from the acids we have just considered.

In the first place, it is a gas, and as such is extremely inconvenient to work with, and is scarcely ever employed in this state. Water will absorb many hundred times its own volume of the gas to give us a solution known in the laboratory as concentrated hydrochloric acid. This solution contains only about 35 per cent. of the pure acid.

Hydrochloric acid is prepared by heating sodium chloride (common salt) with sulphuric acid.

$$\underset{\text{Sodium chloride}}{2NaCl} + \underset{\text{Sulphuric acid}}{H_2SO_4} = \underset{\text{Sodium sulphate}}{Na_2SO_4} + \underset{\text{Hydrochloric acid}}{2HCl}$$

The gas is led off as it is formed into water; the concentrated acid is not nearly so corrosive in its action as sulphuric or nitric acids.

Another difference between this acid and the previous two, is that it contains no oxygen, as a glance at its formula will show. Thus it is not only the non-metallic oxides which will form acids with water. All acids, however, contain hydrogen. Many of them act upon metals to produce hydrogen, this being a common method for preparing this gas.

$$\underset{\text{Zinc}}{Zn} + \underset{\text{Sulphuric acid}}{H_2SO_4} \quad \underset{\text{Zinc sulphate}}{ZnSO_4} + \underset{\text{Hydrogen}}{H_2}$$

$$\underset{\text{Magnesium}}{Mg} + \underset{\text{Hydrochloric acid}}{2HCl} = \underset{\text{Magnesium chloride}}{MgCl_2} + \underset{\text{Hydrogen}}{H_2}$$

The solutions after such a reaction contain salts which can be obtained in a crystalline form by concentrating the solution.

Bases.—The commonest bases are the caustic alkalies, so called on account of their corrosive action upon the skin. Caustic soda or sodium hydroxide, NaOH, and caustic potash, potassium hydroxide, KOH, are largely used in soap-making. The various fats and oils are boiled up with caustic alkali for some time, when the result is the formation of a soap, the process being known as saponification.

Most of the soap works manufacture their own caustic soda and caustic potash by the reaction between lime and sodium carbonate:

$$\underset{\text{Calcium hydroxide}}{Ca(OH)_2} + \underset{\text{Sodium carbonate}}{Na} \quad \underset{\text{Calcium carbonate}}{CaCO_3} + \underset{\text{Caustic soda}}{2NaOH}$$

The characteristic property of alkalies has already been stated. It is to neutralise acids, during which process a "salt" and water are produced:

$$\underset{\text{Sodium hydroxide}}{NaOH} + \underset{\text{Hydrochloric acid}}{HCl} \quad \underset{\text{Sodium chloride}}{NaCl} + \underset{\text{Water}}{H_2O}$$

Hence this gives us another method for preparing that class of bodies known as salts.

Ammonium Hydroxide, NH_4OH.—Ammonia itself is a compound of hydrogen and nitrogen, 3 atoms to 1—NH_3—and is a strong-smelling gas. It will dissolve very readily in water, however, to give a strongly alkaline liquid.

$$\underset{\text{Ammonia}}{NH_3} + \underset{\text{Water}}{H_2O} = \underset{\text{Ammonium hydroxide}}{(NH_4)OH}$$

This liquid is known as ammonium hydroxide, and is very similar to NaOH or KOH if we suppose the (NH_4) group (ammonium) to act just like the metal K or Na. Thus acids and ammonium hydroxide will form ammonium salts and water:

$$\underset{\text{Ammonium hydroxide}}{NH_4OH} + \underset{\text{Hydrochloric acid}}{HCl} = \underset{\text{Ammonium chloride}}{NH_4Cl} + \underset{\text{Water}}{H_2O}$$

Ammonium chloride thus obtained from such a solution in crystals is known as sal ammoniac, and is used in Léclanché cells for electrical purposes.

Lime water, a solution of calcium hydroxide, $Ca(OH)_2$, is also used as an alkali, but it is much weaker than those just considered. This is partly due, of course, to the slight solubility of slaked lime in water. With acids it will form calcium salts. In the neutralisation of sulphuric acid with lime water, we get a white precipitate formed of calcium sulphate, which is nearly insoluble in water.

$$\underset{\text{Calcium hydroxide}}{Ca(OH)_2} + \underset{\text{Sulphuric acid}}{H_2SO_4} = \underset{\text{Calcium sulphate}}{CaSO_4} + \underset{\text{Water}}{2H_2O}$$

A mixture of lime water and olive oil is found to be of great value in relieving burns on the skin caused by acids, the alkali neutralising the acid.

Oxidation and Reduction.—We have considered many substances which burn in the air, and this so-called combustion is due to the combination of the substance with oxygen. Many metals, such as lead, will form oxides when heated in air or oxygen, and the chemical process is known as oxidation.

$$\underset{\text{Lead}}{Pb} + \underset{\text{Oxygen}}{O} = \underset{\text{Lead monoxide or litharge}}{PbO}$$

It is a comparatively easy matter to reverse this process and "deoxidise" the lead oxide. Such a change is known as reduction, and occurs when hydrogen gas is passed over heated lead oxide.

$$\underset{\text{Lead oxide}}{PbO} + \underset{\text{Hydrogen}}{H_2} \quad \underset{\text{Lead}}{Pb} + \underset{\text{Water}}{H_2O}$$

Because hydrogen is able to remove oxygen from the lead oxide, it is termed a reducing agent. Hydrogen, therefore, exerts a superior attraction for oxygen than does lead, and is able to abstract oxygen from its oxide. At the same time, however, the hydrogen itself has become oxidised, as it has combined with oxygen to form an oxide—water, H_2O. Hence oxidation and reduction always go hand in hand; one of the substances is oxidised, the other reduced.

Many other substances can act like hydrogen in reducing compounds. Thus carbon is a common reducing agent:

$$\underset{\text{Lead oxide}}{PbO} + \underset{\text{Carbon}}{C} = \underset{\text{Lead}}{Pb} + \underset{\text{Carbon monoxide}}{CO}$$

$$\underset{\text{Stannic oxide (tin dioxide)}}{SnO_2} \quad \underset{\text{Carbon}}{2C} \quad \underset{\text{Tin}}{Sn} + \underset{\text{Carbon monoxide}}{2CO}$$

Another reducing agent is carbon monoxide, which is capable of taking up a further atom of oxygen to form carbon dioxide.

$$\underset{\text{Carbon monoxide}}{CO} + \underset{\text{Oxygen}}{O} \quad \underset{\text{Carbon dioxide}}{CO_2}$$

Black copper oxide heated in a current of carbon monoxide is reduced to metallic copper.

$$\underset{\text{Copper oxide}}{CuO} \quad \underset{\text{Carbon monoxide}}{CO} \quad \underset{\text{Copper}}{Cu} \quad \underset{\text{Carbon dioxide}}{CO_2}$$

Metals themselves will act as reducing agents upon other metallic oxides by virtue of the fact that they exert greater attraction for the oxygen. The metal aluminium heated to a high temperature with ferric oxide will form aluminium oxide and produce metallic iron.

$$\underset{\text{Ferric oxide}}{Fe_2O_3} + \underset{\text{Aluminium}}{Al} = \underset{\text{Aluminium oxide}}{Al_2O_3} + \underset{\text{Iron}}{Fe}$$

The heat of the reaction is so great that use is made of this in the welding of steel rails, &c. The "Thermite" process depends upon this reaction, and is especially useful when an intense local heat is required, as in the welding of tram rails.

It is well to note that the terms oxidation and reduction are used in a wider sense than that which we have considered. Removal of hydrogen is often termed oxidation, as well as the addition of oxygen. Thus oxygen itself is a reducing agent because it will unite with hydrogen, withdrawing it from a compound.

Sulphuretted hydrogen is a gas with a very offensive odour, and is the cause of the smell of "ripe" eggs. It is prepared in the laboratory

by acting upon ferrous sulphide with hydrochloric acid (dilute):

FeS	$+$	$2HCl$	$=$	$FeCl_2$	$+$	H_2S
Ferrous sulphide		Hydrochloric acid		Ferrous chloride		Sulphuretted hydrogen

A solution of this gas in water, on exposure to air, will deposit sulphur according to the reaction:

$2H_2S$	$+$	O_2		$2H_2O$	$+$	$2S$
Sulphuretted hydrogen		Oxygen		Water		Sulphur

This is really an example of "dehydrogenisation" or of removal of hydrogen.

Chlorine will similarly effect such an oxidation:

H_2S	$+$	Cl_2	$=$	$2HCl$	$+$	S
Sulphuretted hydrogen		Chlorine		Hydrochloric acid		Sulphur

Common Oxidising Agents.—*Potassium Permanganate,* $KMnO_4$.—This substance, the familiar "permanganate of potash," is the chief constituent of Condy's fluid, the well-known disinfectant. The disinfecting properties depend upon its oxidising power, it being fatal to all bacterial life.

Potassium permanganate is a salt, and as such may be regarded as made up of two parts—basic and acidic. In the reactions of this salt we find that a double molecule, $2KMnO_4$, is always used. The formula $2KMnO_4$ may be split up into the basic oxide K_2O and the acidic oxide Mn_2O_7, or $2KMnO_4 = K_2O \cdot Mn_2O_7$. The acidic oxide of manganese breaks down easily into lower oxides with the liberation of oxygen. This change occurs at ordinary temperatures with a solution of $KMnO_4$, and the brown deposit or stain on the sides of the bottle is the lower oxide of manganese, MnO_2, or manganese dioxide, $Mn_2O_7 = 2MnO_2 + 3O$. This reaction affords a cheap method for staining wood, as after painting with a solution of permanganate, reduction of the latter goes on, and a brown stain is left.

Potassium permanganate is used very extensively in the laboratory for oxidising purposes.

Potassium Chlorate, $KClO_3$.—This also is a more or less familiar substance, generally known as "chlorate of potash."

On heating, potassium chlorate first melts and begins to give off oxygen; continued heating completely decomposes it, all the oxygen being liberated:

$2KClO_3$	$=$	$2KCl$	$+$	$3O_2$
Potassium chlorate		Potassium chloride		Oxygen

Chlorine, Cl.—Chlorine is a greenish-yellow gas obtained by acting upon manganese dioxide with hydrochloric acid, which results in the "dehydrogenisation" of the acid; or in other words, the acid is oxidised:

MnO_2	$+$	$4HCl$	$=$	$MnCl_2$	$+$	$2H_2O$	$+$	Cl_2
Manganese dioxide		Hydrochloric acid		Manganese chloride		Water		Chlorine

Chlorine dissolves in water, and the solution has the power to bleach various colouring matters, due to the liberation of oxygen from the water:

Cl_2	$+$	H_2O	$=$	$2HCl$	$+$	O
Chlorine		Water		Hydrochloric acid		Oxygen

A similar reaction is made use of industrially in the employment of bleaching powder. This substance is prepared by passing chlorine over lime ($Ca(OH)_2$), which absorbs it to form $CaOCl_2$:

$Ca(OH)_2$	$+$	Cl_2	$=$	$CaOCl_2$	$+$	H_2O
Calcium hydroxide		Chlorine		Bleaching powder		Water

Bleaching powder will not dissolve in water as such, but undergoes a change with the formation of a substance known as hypochlorous acid, HOCl. This easily gives up its oxygen according to the change:

$HOCl$	$=$	HCl	$+$	O
Hypochlorous acid		Hypochloric acid		Oxygen

In the bleaching of cotton, after boiling with alkali to free from grease, the cotton is washed and then is dipped into the "sour" bath to completely remove all alkali. This "sour" bath is merely a very dilute solution of sulphuric acid. After washing again, the cotton is dipped into the "chemick," which is the bleaching solution, and the oxidising action of the hypochlorous acid, HOCl, then causes the bleaching.

Bromine and Iodine.—These two elements are in the same "family" of elements as chlorine in the periodic classification, and afford a good example of similarity in properties.

Bromine is a dark brown, heavy liquid with a pungent, obnoxious vapour. Its solution in water acts similarly to chlorine water, though not so active. The bromides are salts of hydrobromic acid, HBr, and correspond to the chlorides. Potassium bromide, KBr, sodium bromide, NaBr, and ammonium bromide, NH_4Br, are largely used in medicine on account of their sedative action, and are of great value in nervous diseases.

Iodine exists in black shining scales which give a beautiful violet vapour when warmed. It is only very slightly soluble in water, the solution being brown in colour. This solution, however, is a feeble oxidising agent, but some of its salts have strong bleaching powers. The corresponding acid to hypochlorous acid, namely hypoiodous acid, HIO—a very unstable substance—decomposes in a similar manner.

HOI	$=$	HI	$+$	O
Hypoiodous acid		Hydoiodic acid		Oxygen

An alcoholic solution of iodine is known as "tincture of iodine," and is very extensively used in medicine and surgery as an antiseptic.

Electrolysis.—We have already come across an example of electrolysis, in the decomposition of water by the electric current. It was stated that it was necessary for the water to be slightly acidulated, as pure water will not conduct electricity. Substances may be divided into

two classes—conductors and non-conductors of electricity. Acids, bases, and salts are examples of the first class, while such substances as sugar, urea, &c., which, when dissolved in water, will not conduct a current of electricity, are of the second class.

Evidently, then, there must be a difference in the condition of the particles, say, of salt (NaCl) and sugar when dissolved in water. Electrolysis of a solution of sodium chloride causes evolution of hydrogen from one electrode (cathode), and chlorine from the other (anode). Now the hydrogen must have come from the decomposition of the water in some way, whilst the chlorine has been liberated from the salt. The fact that the solution becomes alkaline shows that sodium hydroxide has been formed. The only explanation that we can offer is that sodium has been liberated, which decomposes the water, evolving hydrogen and forming caustic soda.

Thus, by means of an electric current, sodium chloride has been decomposed into sodium and chlorine. The chlorine is liberated as such, but it is not possible to isolate the sodium owing to its immediate reaction with water.

The question at once arises as to the difference in the condition of the sodium and chlorine before and after passing the current. The fact is, that on dissolving sodium chloride in water, the salt is split up into its two component parts. A molecule is not split up, however, into sodium and chlorine atoms—otherwise an immediate chemical reaction would occur. The molecule of sodium chloride is decomposed into an atom of sodium plus an electric charge, and also a chlorine atom carrying an electric charge. This combination of an atom with a charge of electricity is termed an "ion," and we speak of such particles as sodium ions and chlorine ions. The presence of an electric charge causes the particular atom to exhibit none of the characteristic chemical charges of the element.

A fundamental law in magnetism and electricity is that "like poles repel, and unlike poles attract." That is to say, there will be mutual repulsion between two bodies carrying the same kind of electric charge, and mutual attraction if they carry charges of the opposite kind. Now in a solution of sodium chloride the sodium atom is combined with a positive electric charge to form the sodium ion; similarly, the chlorine united with a negative charge to form a chlorine ion. On dipping the terminals of a battery into the solution, the sodium ions are attracted towards the negative electrode—the cathode—and the chlorine ions towards the positive electrode—the anode. When they arrive at these electrodes, their electricity is discharged, and they become ordinary chemical atoms. In the case of the chlorine atoms, they unite to form molecules, and the gas is liberated. With the sodium, however, we get immediate decomposition of the water with the liberation of hydrogen.

This in general is what occurs in all cases of electrolysis. The atom charged positively, and which travels to the negative electrode (cathode) is termed the "cation," whilst the ion charged negatively, and attracted to the anode, is known as the "anion."

In the case of copper sulphate, $CuSO_4$, electrolysis of a solution will give us copper ions and sulphate (SO_4) ions. The (SO_4) group travels as a whole with its electric charge to the anode, where it is discharged, and immediately reacts with water to form sulphuric acid and liberates oxygen.

$$\underset{\text{Sulphate ion}}{(SO_4)} + \underset{\text{Water}}{H_2O} = \underset{\text{Sulphuric acid}}{H_2SO_4} + \underset{\text{Oxygen}}{O}$$

The copper ion travels to the cathode and is there deposited, after losing its charge. These changes will occur if the electrodes are made of a metal not easily attacked, such as platinum. If copper is used, however, the sulphate ion (SO_4) reacts with the copper to reform copper sulphate. This fact finds application in the preparation of pure copper. The crude copper is made into thick bars and forms the anode. A strip of pure copper is the cathode, and in passing a current through a solution of copper sulphate, the copper is deposited in a pure condition upon the cathode. The reaction between the (SO_4) group and the copper anode to form copper sulphate thus goes on until practically all the crude copper has disappeared, and the deposit of pure copper on the cathode obtained.

The whole principle of the art of electroplating is based on precisely similar reactions, the object to be plated being made the cathode. Thus if we electrolyse a solution of silver nitrate, $AgNO_3$, between, say, an anode of silver and a cathode of a baser metal, the cathode will become covered with a deposit of silver. The (NO_3) ion will travel to the silver anode and will there form silver nitrate, so that the process can be made to continue until most of the silver anode has dissolved. A much better and uniform deposit of silver upon the article to be plated is obtained if silver cyanide, AgCN, is used. Plating with nickel, gold, platinum, &c., is performed similarly, the plated articles being afterwards burnished.

Organic Chemistry.—For centuries past there have been two main divisions of chemistry—organic and inorganic—and all substances were classed under one or other of these branches. Consideration of the bodies of inorganic chemistry has hitherto been the subject-matter of this article, and we now turn for a brief discussion of the other class of substances. The term "organic" chemistry was employed to signify only those compounds which had been produced by life processes. Some "vital force" was necessary for their formation, and thus it was not possible to prepare such substances in

the laboratory owing to the absence of the essential organised life. That all such bodies contained the element carbon was shown by the charring when they were heated, and the formation of carbon dioxide during their combustion. Carbon, hydrogen, oxygen, and nitrogen, were the chief constituents of the larger part of the "organic" compounds. Many of them also contained the halogens—chlorine, bromine, and iodine, while a smaller proportion still were compounds of sulphur and phosphorus.

In the main, the old idea was correct, and we recognise that the majority of organic substances are comprised under these groupings. The general scope, however, of the subject has been much extended, and the most general definition of organic chemistry to-day is "the chemistry of the carbon compounds." The idea of the part played by the living organism was dispelled finally by Wöhler in 1828. Urea, that typical "organic" substance found in the urine of most animals, was prepared artificially from inorganic substances. This was the starting-point, and since Wöhler's time many thousands of similar "organic" compounds have been synthetically prepared, without reference whatever to any vital force.

At the same time, however, we recognise that the vast majority of the carbon compounds are more or less intimately connected with plant and animal life and decay.

Organic chemistry covers a much wider ground than does the inorganic branch, and at the present time probably something like 250,000 substances are known. This number is ever increasing as new substances are being discovered every week. This fact is due to the immense research development of the last few decades. Scientific research in Germany especially has been very productive in enlarging the enormous list of the carbon compounds.

In another way, too, organic chemistry enters much more closely into our life. The employment of so many organic substances in medicine has found such wide application, that we have many sub-branches of the subject. Physiological and pharmacological chemistry may be instanced as two co-ordinated branches which investigate the action of various drugs, &c., on the human body, and the modifications in these actions caused by change in chemical structure or composition.

Carbon.—Before proceeding to the discussion of the compounds of carbon, it will be well to briefly consider the element itself. The peculiar property of carbon is that it exists in three distinct forms, which differ vastly one from another. Diamond, graphite, and charcoal have very little in common with each other as regards appearance and physical properties. Chemically, however, they are the same substance, and we can prove this fact in a number of ways. *Diamond* is the form of carbon which has been subjected to an intense heat and an enormous pressure, and then allowed to slowly crystallise. *Graphite* is the crystalline form obtained by the more rapid crystallisation from molten iron. *Charcoal* is an amorphous (non-crystalline) substance obtained when many substances, *e.g.* sugar, are burnt. Now diamonds can be artificially prepared from charcoal, first made possible by Moissan with his electric furnace. The charcoal is dissolved in molten iron, which is suddenly cooled by pouring into water. The outer shell is thus caused to contract and imprisons the still molten metal inside. As this latter very slowly cools, it tends to expand considerably on solidifying, but as it is firmly enclosed in an unyielding envelope, tremendous pressure results. Under these conditions the dissolved carbon separates as crystals—diamonds. The iron is removed by dissolving out with acid, and the diamonds remain. These are far too minute to be used as gems, but are employed in polishing and cutting. The reverse of this conversion of charcoal into diamond may be brought about by intensely heating diamond, when it is resolved into the amorphous carbon. Further proof of the identity of these two forms is seen when both are burnt. From equal weights of diamond and charcoal we get the same weight of carbon dioxide.

The formation of diamond from charcoal gives us some idea as to the origin of diamonds in nature. We know that deep down in the earth matter exists in a molten condition. Here, beneath the tremendous pressure of hundreds of miles of rock, is molten iron and other metals which are heated to an immense temperature. All carbonaceous matter, in common with everything else, would be in a fused condition, probably globules dissolved in the molten metal. Volcanic or other upheaval would bring this mixture near the surface, and the slow cooling of the mass would cause the carbon to crystallise out in the form of diamonds.

This view of things is supported by the fact that many diamonds are found in a spherical form, and often explode upon very slight provocation. The interior of the diamond is still under a very great strain, owing to the solidifying of the outer portion first. A comparable condition of affairs is found in "Rupert's Drops." Molten glass is dropped into a depth of water which cools the outside quickly, and the inside is in a molten condition. The very slow cooling of this causes a great strain to be set up, and the pressure is released when the "drop" is hit with a hammer, with the result that the glass explodes into a thousand fragments.

Minute cavities filled with highly-compressed gas are often present in diamonds. Again we have a state of internal strain, and the pressure of the liquid carbon dioxide in these cavities often causes the diamonds to burst soon after being brought to the surface.

The properties of the diamond are too familiar to require much explanation. The expression "diamond cut diamond" is, of course, an allusion to its extreme hardness, which will allow it to scratch anything, while the value as a gem depends upon its power of reflecting and refracting light.

Graphite, the second modification of carbon, is the well-known "black lead," so called because of its resemblance to lead, and to the similar property of marking paper, which finds application in the manufacture of "lead" pencils.

Graphite is a soft black substance with a metallic lustre, conducts electricity very well, which property is used in the making of moulds for the deposition of metals used in electrotyping. One of the most important properties of graphite, however, is its infusibility. This involatility finds application in the manufacture of such vessels as crucibles which are to be used at a very high temperature. Similarly, its use as a lubricant for revolving machinery, for which ordinary lubricating oils are inapplicable because of the high temperature.

The formation of graphite in nature gives us another insight into those wonderful cosmic changes which have been in progress through the ages. There is but little doubt that the graphite has been produced by the working of underground forces upon coal.

Coalfields sink down sufficiently deep to become acted upon by the great heat and pressure in the interior of the earth, and the transformation to graphite is effected. Subsequent great earth movements again bring the carbon to the surface in the form of graphite.

The third form of carbon is probably the commonest of all. It exists in many varied forms, such as soot or lampblack, gas carbon, and charcoal. Gas carbon is the porous substance left in the retorts after the distillation of coal, and its extensive use in arc lamps is well known.

Charcoal itself—one of the purest forms of carbon, is formed by heating many substances in closed vessels. Sugar, bones, wood, blood, &c., when so heated give us a powder which is used largely for disinfecting purposes. The power of absorbing noxious gases is due to its honeycomb structure, which is of a very complex character. The oxygen contained in the pores of the carbon thus offers a very large surface for oxidising such vapours into harmless compounds. Nor is the oxygen in these pores in its ordinary condition. It is highly compressed—so as to be almost liquid probably—and as such it possesses very high efficiency in oxidisation.

The use of charcoal in sugar-refining depends upon the same principle—namely, the absorption of colouring and other matters into the pores of the carbon, yielding a purified and decolorised product.

Properties of Carbon.—Some idea as to the unique properties of carbon in its different forms has now been obtained, and will enable us to understand perhaps the multitude and variety of its compounds. Gases, liquids, and solids possessing odours, colours, and appearances of a vastly different character make up the substances known as organic compounds. The sweet-smelling essences, oils, and perfumes, as well as the evil-smelling products of organic decay, are compounds of carbon. The majority of drugs invaluable in medicine; the characteristic constituents of tea, coffee, cocoa; practically all our food-stuffs; the greater number of colouring matters, and most explosives, are all compounds of carbon.

We have already noted that there is such a thing as chemical attraction between various elements. Thus hydrogen and oxygen have an affinity for one another to form water; with chlorine, hydrogen forms hydrochloric acid; most metals and oxygen have an attraction one for the other to form metallic oxides.

Now carbon stands out from all other elements in that it has a very great affinity for itself, and the explanation of the huge number of compounds of carbon is to be found in the attraction between atom and atom.

In order to understand the way in which organic compounds are built up, it will be well to introduce briefly what is known as the molecular structure of matter.

All substances are made up of immensely tiny particles of matter known as molecules. The distinction between such particles and atoms has already been treated in the early part of this article.

Now these tiny particles of every substance are in constant motion. The movements are greatest in the case of gases, where we have these particles or molecules constantly colliding with one another and bombarding the sides of the containing vessel. It is this bombardment which constitutes the pressure of a gas. If we raise the temperature of a gas we increase the pressure, due to the fact that we have quickened the movements of the molecules. Similarly, if the pressure is increased, the bombardment against the sides of the vessel will be increased, and the temperature will be raised in consequence. Hence the heat formed during the inflation of a bicycle tyre, where we have compression of the air in the pump, which pushes the molecules closer together, increasing their velocities and the number of times of their collisions.

In liquids the molecules are in a rapid state of motion, but they are closer together and are not moving so quickly as in the case of gases.

The molecules in the case of solid bodies are still in motion, but their movement is strictly limited, and the motion probably consists of a vibration about a fixed position. This is very

different from the molecules in liquids and gases, which are free to move in all directions.

Of course we cannot actually see molecules because of their very minute size. It has been estimated that were a single small drop of water enlarged to the size of the earth, the molecules would probably be of the size of small shot. Put in another way, the smallest drop of water which can be seen under a powerful microscope, would probably contain between 60 and 100 million molecules.

The task of investigating the composition of such minute particles would seem to be an impossible one, either for the chemist or anyone else. The actual arrangement of the atoms in the molecule certainly is more or less beyond us at the present time. Yet the chemist has been able to obtain a clear mental picture of such arrangements, which answers many purposes, and enables us to comprehend the reactions of substances. The molecule represents on a very minute scale what a mass of the substance itself does on the larger scale. That is to say, the molecule is regarded as possessing all the properties of the smallest visible particle which is made up of a huge number of the same molecules. A building is made up of many bricks—very small in comparison to the building itself—yet there is a definite number, and the nature of the building depends upon the arrangement of these bricks. So with the architecture of the molecule, it is made up of a definite number of minute pieces called atoms, and the properties of the molecule depend upon the arrangement, number, and properties of these atoms.

Valency.—In order to learn something of the forces which hold atoms together, let us take four compounds such as hydrochloric acid, HCl, water, H_2O, ammonia, H_3N, and marsh gas or methane, H_4C. Here we have an increase in the hydrogen atoms from 1 to 4 which are combined with 1 atom of chlorine, oxygen, nitrogen, and carbon respectively. Evidently there is a difference between the power with which each of these atoms can hold the atoms of hydrogen. The name given to this power is "valency," and hydrogen is taken as the standard of valency, because no substance is known which will combine with less than 1 atom of hydrogen. Hydrogen, therefore, is termed a monovalent element, and similarly chlorine, bromine, &c., which will combine with hydrogen atom for atom. Oxygen will therefore be a divalent element, as it will hold 2 hydrogen atoms.

Because nitrogen will attract 3 hydrogen atoms to form a stable structure such as the molecule of ammonia, it is here called a trivalent element. Carbon is tetravalent, as it is satisfied with holding 4 atoms of hydrogen. It is necessary to add, however, that 4 is not the limit of the atom-holding power of any element. The maximum number of monovalent atoms, such as hydrogen or chlorine, which can form a stable molecule, is 6 with certain elements. Thus, although we have pentavalent and hexavalent atoms in many compounds, yet the great majority of the bodies which we shall consider will be included under the valencies 1 to 4.

In one respect the number of monovalent atoms which can unite with a single atom of an element is not altogether rigid. Thus nitrogen can be both trivalent and pentavalent, as in ammonia, NH_3, and ammonium chloride (sal ammoniac), NH_4Cl. The white fumes produced when ammonia and hydrochloric acid gas are brought into contact is due to the combination of the two substances:

NH_3	HCl	NH_4Cl
Ammonia	Hydrochloric acid	Ammonium chloride

and the further addition of the two monovalent elements—hydrogen and chlorine—causes the changes in the valency of the nitrogen from 3 to 5. Phosphorus undergoes similar changes, and we have compounds such as phosphorus trichloride, PCl_3, and phosphorus pentachloride, PCl_5.

There is a limit, however, to the maximum number of atoms to which an atom of any element can attach itself.

In the case of hydrogen and chlorine this is 1; with nitrogen and phosphorus it is 5; with the element carbon it is 4.

The carbon atom, with two doubtful exceptions, is consistently tetravalent in all its many thousand compounds, and this affords a further distinguishing mark of organic chemistry.

The usual method of indicating the number of atoms with which an atom is combined is by means of short lines:

$$\mathrm{H—},\ \mathrm{—O—},\ \mathrm{N}\!\equiv,\ \mathrm{C}\!\equiv\!\!\!\equiv \text{ or } \begin{array}{c} | \\ —\mathrm{C}— \\ | \end{array}$$

The various compounds taken above as a type would thus be written, H—Cl, H—O—H,

$$\mathrm{N}\begin{array}{l} \diagup \mathrm{H} \\ —\mathrm{H}, \\ \diagdown \mathrm{H} \end{array} \quad \begin{array}{c} \mathrm{H} \\ | \\ \mathrm{H—C—H} \\ | \\ \mathrm{H} \end{array}$$

We are going to confine ourselves now to the consideration of the combinations of various atoms with carbon atoms.

Combinations with the Carbon Atoms.—One of the simplest carbon compounds is the one already mentioned—marsh gas or methane, CH_4. This is the chief constituent of the deadly "firedamp" of coal mines, owing to its explosive combination with oxygen when a light is brought to a mixture. Such an explosion takes place according to the equation:

$$\underset{\text{Methane or marsh gas}}{CH_4} + \underset{\text{Oxygen}}{O_2} = \underset{\text{Carbon dioxide}}{CO_2} + \underset{\text{Water}}{2H_2O}$$

The carbon dioxide thus formed is the "choke"

or "after" damp which claims so many victims by suffocation after an explosion.

Under ordinary circumstances, methane will burn with a bluish flame quite harmlessly.

Methane may be regarded as the starting-point from which many compounds are derived. By replacing 3 hydrogen atoms we get the well-known liquid chloroform, $CHCl_3$, which is by far the most useful and common anæsthetic employed in medicine. If the substitution is proceeded with a stage farther, carbon tetrachloride, CCl_4, is the resulting liquid. This is a sweet-smelling liquid, not unlike chloroform, and is largely used as a solvent. Many so-called "dry" shampoos are merely solutions of soap in carbon tetrachloride.

These two liquids are the more important of the four substitution products which can be obtained from methane. Both CH_3Cl, methyl chloride, and CH_2Cl_2, methylene dichloride, are formed by the successive replacements of one or two hydrogen atoms by chlorine.

Now, at first sight, the study of organic chemistry, with its vast number of compounds, would appear a very complicated affair. Yet, by applying the principle of substitution, it is possible to reduce the science to a very orderly state. We can regard all organic compounds as being derived from one of a general type or class, and in this way a very systematic and helpful connection between substances can be made.

The acid of vinegar, known chemically as acetic acid, is methane with a compound group (COOH) replacing one hydrogen atom, giving the body $CH_3(COOH)$. It is difficult, of course, to see much connection between the colourless gas methane and the reeking sour liquid, acetic acid. Because of this it is found much better to regard acetic acid itself as one of a class of similar bodies under the general heading of acids. Acetic acid can be similarly treated with chlorine, and by the introduction of one, two, or three atoms we get the bodies monochloracetic, dichloracetic, and trichloracetic acids, $CH_2ClCOOH$, $CHCl_2COOH$, CCl_3COOH. All of these substances are acids behaving chemically in a similar manner to acetic acid.

Analogy of the molecule to the building again is helpful in explaining both the similarity of substituted bodies and differences in others. Various bricks may be replaced by larger or smaller bricks or different materials without altering the general appearance or properties of a building. If we were to try to replace too many bricks, however, say with wood or even iron, the building would become unsafe, and probably collapse entirely. In the same way, replacement in chemical compounds has its limit, and if we proceed too far the molecule will be broken up and new substances formed.

The Alcohols.—Many organic compounds may be supposed to be derived from water, H—O—H. The class of bodies known generally as alcohols may be so regarded. Alcohol in common parlance is ethyl alcohol, C_2H_5—O—H, and here we have the compound group (C_2H_5) replacing a hydrogen atom in the water. The common properties of alcohol are well known, and do not need enumeration here. In chemical properties alcohol may well be compared with the alkalies potash, KOH, or soda, NaOH, derived from water by substitution of potassium or sodium.

Potash will react with acids to form salts such as potassium chloride, KCl, potassium nitrate, HNO_3, potassium acetate, $KC_2H_3O_2$, &c. Similarly, alcohol will react to form ethyl chloride, C_2H_5Cl, ethyl nitrate, $C_2H_5NO_3$, and ethyl acetate, $C_2H_5 \cdot C_2H_3O_2$.

KOH Potassium hydroxide	+	HCl Hydrochloric acid	=	KCl Potassium chloride	+	H_2O Water
C_2H_5OH Ethyl alcohol	+	HCl Hydrochloric acid	=	C_2H_5Cl Ethyl chloride	+	H_2O Water

The idea of substitution may be carried farther by considering the oxide $C_2H_5 \cdot O \cdot C_2H_5$ analogous to NaONa (Na_2O), where both the hydrogen atoms in the water have been replaced. This substance $(C_2H_5)_2O$ is the ethereal-smelling liquid ether—used as a minor anæsthetic by itself, and generally is mixed with chloroform when this latter is administered.

The comparison breaks down, however, when we try to isolate the grouping (C_2H_5) similar to the way in which we can obtain sodium or potassium. This reminds us that after all the idea of substitution and comparison is purely theoretical, and although it is of immense assistance in forming correct views of chemical constitution, yet there are limits in its application. The (C_2H_5) group is known as the ethyl "radicle," this latter term being given to such a group of elements which is capable of being moved and replaced from one compound to another without changing. Thus we have ethyl alcohol, ethyl chloride, ethyl acetate, &c., all containing the (C_2H_5) radicle intact, although it is impossible to isolate this group so that it has a separate existence.

Radicles may be either of a simple or complex nature—methyl (CH_3), ethyl (C_2H_5), propyl (C_3H_7), &c., being comparatively simple.

Whether simple or complex, however, the underlying principle is the same—namely, the affinity existing between the atoms of carbon. This mutual attraction is exerted to give chains of carbon atoms—C—C—C—. Sometimes these are open chains, as in alcohol:

$$\begin{array}{ccccc} & H & & H & \\ & | & & | & \\ H- & C & - & C & -O \cdot H \\ & | & & | & \\ & H & & H & \end{array}, \text{ ethyl chloride, } \begin{array}{ccccc} & H & & H & \\ & | & & | & \\ H- & C & - & C & -Cl \\ & | & & | & \\ & H & & H & \end{array}$$

and we have also compounds containing hundreds, and even thousands, of carbon atoms all joined together in a similar fashion. Many of our commonest substances in everyday use are of this nature. Thus starch is supposed to have a formula of the order of $C_{1200}H_{2000}O_{1000}$; cellulose (cotton wool is one of the forms) has a constitution like $C_{6000}H_{10000}O_{5000}$. One can imagine how heavy must be a molecule with such a structure as this. Such bodies are so complex that at present we have not been able to determine very much about the properties of the molecule. For convenience in representing the reactions, we use the simplest submultiples of the above numbers $C_6H_{10}O_5$. Of a similar nature are the sugars, which are of two classes, like grape sugar, $C_6H_{12}O_6$, and cane sugar, $C_{12}H_{22}O_{11}$. These formulæ are the simplest representations which we can give to the signs, although in all probability they are much more complex. It is of interest to note that the term carbohydrate is given to all such bodies as starch, cellulose, and sugar where the hydrogen and oxygen are present in molecular proportions to form water. This was the origin of the term, grape sugar being regarded as a mixture of carbon and water, thus, $C_6(H_2O)_6$. This erroneous view has now been superseded, but the name remains.

Value of Structural Formulæ.—There are three kinds of linkings in these open-chain compounds where the carbon atoms have a different relation one to another. In the hydrocarbon ethane,

$$C_2H_6, \text{ or } \begin{array}{ccccccc} & & H & & H & & \\ & & | & & | & & \\ H & — & C & — & C & — & H \\ & & | & & | & & \\ & & H & & H & & \end{array}, \text{ which is very similar}$$

to methane, the carbon atoms are singly linked, and therefore the reactions of the molecule are not the same as those of an ethylene

$$C_2H_4 \text{ or } \begin{array}{ccccccc} & & H & & H & & \\ & & | & & | & & \\ H & — & C & = & C & — & H \end{array}, \text{ where the carbon atoms}$$

are doubly linked. Then there is a third way in which the atoms are joined, as in the gas acetylene, C_2H_2 or $H–C{\equiv}C–H$, where there is a trebly-linked pair of atoms of carbon.

Now it must not be thought that these structural formulæ indicate anything more than a helpful representation to assist us in the study of carbon compounds. They do not present the actual arrangements of the atoms in the molecule, but are merely convenient symbols. At the same time there has to be associated with these groups C–C, C=C, and C≡C, certain peculiar and distinct properties. Thus ethane, C_2H_6, is known as a saturated compound, referring to the fact that all the atom-fixing powers of each of the carbon atoms is being exerted to the fullest extent. No further addition can be made to the molecule to form a new compound—only substitution in place of hydrogen atoms. With ethylene, C_2H_4, we have the double bond between the carbon atoms to make up the required valency of the carbon to 4. Here we have what is known as an "unsaturated" body—the full powers of the carbon atoms not being satisfied. Thus by the action of hydrogen we can cause two further atoms to be added to give ethane, C_2H_6. Chlorine, bromine, iodine, &c., will also unite directly to give $C_2H_4Cl_2$ or

$$\begin{array}{ccccccc} & & H & & H & & \\ & & | & & | & & \\ H & — & C & — & C & — & H \\ & & | & & | & & \\ & & Cl & & Cl & & \end{array}, \text{ \&c. It would seem, therefore,}$$

that in such a body as ethylene the C=C group is not so stable as the C—C in ethane, and all bodies containing such a doubly-linked pair of atoms will form additive compounds.

Acetylene, C_2H_2, is even more "unsaturated," and will join on directly four monovalent atoms to form ethane and its derivatives. Hence chemically it is regarded as even more unstable than ethylene.

The Paraffins.—Methane, CH_4, and ethane, C_2H_6, belong to a class of hydrocarbons known as the paraffins, so called because of their general indifference to the action of chemical reagents (*parum affinis* = not much affinity). Thus the usual strong acids sulphuric, nitric, &c., and powerful oxidising agents like potassium permanganate, do not have any effect on these bodies at all. There is a regular series of these bodies which may be regarded as derived from methane itself by successive substitutions of (CH_3) groups for hydrogen atoms. Thus from methane,

$$\begin{array}{ccccc} & & H & & \\ & & | & & \\ H & — & C & — & H \\ & & | & & \\ & & H & & \end{array}, \text{ we derive ethane, } \begin{array}{ccccccc} & & H & & H & & \\ & & | & & | & & \\ H & — & C & — & C & — & H \\ & & | & & | & & \\ & & H & & H & & \end{array},$$

and from this latter propane:

$$C_3H_8 \text{ or } \begin{array}{ccccccccc} & & H & & H & & H & & \\ & & | & & | & & | & & \\ H & — & C & — & C & — & C & — & H \\ & & | & & | & & | & & \\ & & H & & H & & H & & \end{array},$$

and so on. We have therefore an increase of (CH_2) in each higher member of the series, and such a series is known as "homologous." Naturally the derivatives of the hydrocarbons themselves form similar homologues. CH_3Cl from methane, C_2H_5Cl from ethane, C_3H_7Cl from propane, &c. Also the alcohols—methyl alcohol, $CH_3 \cdot OH$, obtained, as it were, by substituting an (OH) for (H) in methane, ethyl alcohol, C_2H_5OH, similarly from ethane.

Direct substitution products are obtained from the paraffins by treating with halogens.

Thus from propane we get a number of such products, one of which is tribrompropane, $C_3H_5Br_3$. Boiling this compound with potash converts it into glycerine, $C_3H_5(OH)_3$:

$$\underset{\text{Tribrom-propane}}{C_3H_5Br_3} + \underset{\text{Potassium hydroxide}}{3KOH} = \underset{\text{Glycerine}}{C_3H_5(OH)_3} + \underset{\text{Potassium bromide}}{3KBr}$$

Compounds of Glycerine.—Glycerine is an alcohol, and because it contains three hydroxyl (OH) groups, is known as a trihydric alcohol. Ethyl alcohol, C_2H_5OH, is a monohydric alcohol, and by passing ethylene into potassium permanganate we can get a trihydric alcohol known as glycol, $C_2H_4(OH)_2$.

Alcohols are usually given the termination "ol" and on this account glycerol is really a better name than glycerine.

Now just as ethyl alcohol reacted with acids —both organic and inorganic—to give us ethereal salts, so glycerol will yield similar derivatives. Thus we have glyceryl chloride, $C_3H_5Cl_3$, glyceryl nitrate, $C_3H_5(NO_3)_3$, glyceryl acetate, $C_3H_5(C_2H_3O_2)_3$; and in each case three molecules of the monobasic acids are required. It will be observed that a new radicle is introduced—glyceryl (C_3H_5).

Compounds of glyceryl with the radicles of certain organic acids are the chief constituents of oils and fats. Generally there is a mixture of three of these ethereal salts—named glycerides—and the nature of the fat or oil depends upon the proportions of each present. The acids themselves are palmitic, stearic, and oleic acids, and have rather complex formulæ—palmitic acid, $C_{16}H_{31}O_2 \cdot H$; stearic acid, $C_{18}H_{35}O_2 \cdot H$, and oleic acid, $C_{13}H_{31}O_2 \cdot H$. All these are monobasic acids, and by taking three molecules of each and replacing the three hydrogen atoms with the glyceryl (C_3H_5) group, we get the ethereal salts or glycerides:

Glyceryl palmitate $(C_{16}H_{31}O_2)_3C_3H_5$;
Glyceryl stearate $(C_{18}H_{35}O_2)_3C_3H_5$;
Glyceryl oleate $(C_{18}H_{31}O_2)_3C_3H_5$.

It is the characteristic property of ethereal salts or esters to free the alcohol when boiled with caustic alkalies. This is what happens in the process of soap-making. Fats and oils are boiled with either caustic soda or potash, when we get glycerol and the sodium or potassium salts of the acids:

$C_{16}H_{31}O_2Na$, sodium palmitate;
$C_8H_{35}O_2Na$, sodium stearate;
$C_{18}H_{31}O_2Na$, sodium oleate.

Such a mixture of the sodium salts gives a hard soap, whereas the potassium salts give a soft soap. This process of saponification is the source of all our glycerol of the present time.

The glyceryl nitrate, $C_3H_5(NO_3)_3$, has been mentioned; it is better known as the explosive nitro-glycerine, and is prepared by acting upon the gylcerol with nitric acid. Like many other nitro bodies, it causes a great increase in blood pressure when rubbed between the fingers, and great care has to be taken by the workers in the manufacture of these explosives.

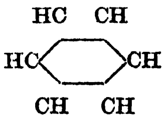
Aromatic Compounds.—All these bodies are examples of the union of carbon atoms in an open chain. Benzene, C_6H_6, on the other hand, is a compound in which the carbon atoms are regarded as being of a ring formation, where we have six (CH) groups united. As benzene forms the basis of many important compounds, it would be well to give it a little consideration. The term "aromatic" was applied to many compounds such as balsams, gums, and resins, which possessed a peculiar odour, and which, when split up, gave benzene and its derived products. In contradistinction to these bodies, there were the "fatty" or "aliphatic" compounds derived from fats, oils, &c. The differentiation is a more or less good one, and at the present time we include all compounds of the nature of benzene, *i.e.* with closed chains of six carbon atoms, under the term "aromatic." On the other hand, "aliphatic" is applied to practically all the open-chain compounds.

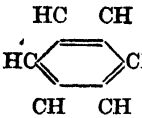
Benzene is obtained from the distillation of coal tar, and is quite a different body from benzine. This latter liquid, together with benzoline and petrol, which are very similar to one another, occur in petroleum oil, and are all examples of aliphatic compounds. At the same time, though, all these substances—benzene, benzine, petrol, naphtha, &c.—have many properties in common. Great inflammability, similarity in smell, useful solvent action for grease, resins, and rubber, are examples of such properties.

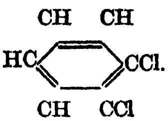
Benzene, then, is obtained from coal tar, and forms the starting-point for all aromatic compounds. The principle of substitution obtains here just as much as with aliphatic bodies. The radicle (C_6H_5) known as "phenyl" differs from aliphatic radicles on account of the different arrangement of the carbon atoms. The properties of the substituted compounds obtained from benzene as a general rule show marked differences from the open chain compounds. Thus phenol or carbolic acid, C_6H_5OH, shows very different reactions from those of alcohol. When pure, it is a white crystalline body with the characteristic smell, but on exposure to air it turns pink and then brown. It corrodes the skin and is a powerful antiseptic. Acids do not affect it, but alkalies such as soda and potash form salts known as phenates, C_6H_5OK.

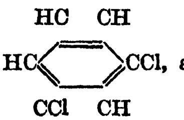
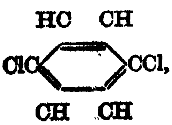
Phenol shares the general property of aromatic compounds in being much more stable than the corresponding aliphatic compounds. They are much more difficult to decompose, this fact being due, of course, to the greater stability of the six carbon atoms in the benzene nucleus. Thus phenyl chloride or chlorobenzene, C_6H_5Cl,

is a liquid much more difficult to split up than ethyl chloride, C_2H_5Cl.

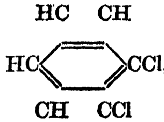
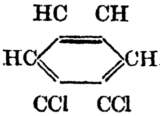
It has been stated that benzene is regarded as an example of a closed chain compound of carbon. Kékulé, in 1865, was led to this conclusion because of the peculiar properties of benzene. Thus in some ways it resembled the paraffin hydrocarbons in forming substitution products like C_6H_5Cl, and in other ways like ethylene, because it would form additive products like $C_6H_6Cl_2$, $C_6H_6Br_4$, and $C_6H_6Cl_6$. These latter bodies, however, were difficult to obtain, and benzene showed none of the willingness of ethylene to join itself with monovalent atoms of the halogens or hydrogen. Giving a hexagon formula of the nature  neither shows the unsaturated condition of the molecule, nor the proper tetravalency of carbon. Kékulé suggested that the hexagon formula be used with three alternate double bonds, thus:

 This would then indicate that there could be additive products formed by combining with two, four, or six monovalent atoms, which is known to be the case. Other formulæ have been suggested, but at the present time no one satisfactory formula has been established and Kékulé's is the best for general use.

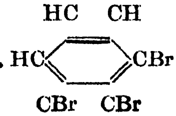
Substitution of one chlorine atom gives us the chlorbenzene, C_6H_5Cl, and, as only one such body is known, the equality of the hydrogen atoms in the molecule is confirmed. Substitution of two chlorine atoms, however, gives rise to three different dichlorbenzenes, owing to the different positions in the so-called ring. Thus, if the chlorine atoms be joined to adjacent carbon atoms, we get "ortho" dichlorbenzene, .

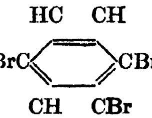
Then the "meta" dichlorbenzene is given if the chlorine atoms are separated by an intermediate carbon atom thus, , and the third compound, "para" dichlorbenzene, , with two carbon atoms between.

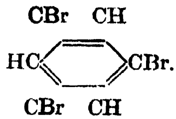
Isomerism.—All these compounds are said to be "isomeric," and the term "isomerism" is applied generally to different compounds which contain the same number of identical atoms, the difference in properties being due to different positions in the molecule.

In the case of the "ortho" dichlorbenzene, we see an objection to the formula of Kékulé. Really there should be two such bodies according to whether the chlorine atoms were separated by a single or a double bond, , or . Only one such compound is known, however.

Isomerism is also seen in the tri-substitution products of benzene, and again three such compounds are known.

Thus 1 : 2 : 3 tribrombenzene, ;

1:2:4 tribrombenzene, ,

and 1 : 3 : 5 tribrombenzene, .

The numbers 1 to 6 are conveniently employed when we are dealing with compounds with more than two substituted atoms or groupings.

So far we have been dealing only with one benzene ring and the substitution of single atoms only. Groupings may be substituted quite similarly, however, to give hydrocarbons more or less resembling benzene. Toluene, which is also found in coal tar, and distils over with the benzene, is methyl benzene, $C_6H_5(CH_3)$. There are three xylenes also which are again very similar in properties, &c. These are ortho-, meta-, and para-dimethyl benzenes, $C_6H_4(CH_3)_2$.

Some idea of the complexity of organic compounds can now be obtained when it is considered that we may have many benzene nuclei linked together directly or indirectly, with complicated substitutions and side chains.

Benzene is acted upon by nitric acid to give a yellow oily liquid with a characteristic smell resembling "oil of almonds":

$$\underset{\text{Benzene}}{C_6H_6} + \underset{\text{Nitric acid}}{HNO_3} = \underset{\text{Nitro-benzene}}{C_6H_5NO_2} + \underset{\text{Water.}}{H_2O}$$

Nitro-benzene is obtained in much larger quantity if the nitric acid be mixed with strong sulphuric acid, which will take up the water formed and so assist the reaction.

Aniline.—If the nitro-benzene be treated with iron and acetic acid, which will form "nascent" hydrogen, reduction occurs, and we get aniline. Pure aniline is a practically colourless liquid, with a peculiar aromatic odour, and on exposure to air and light quickly darkens. Aniline is the starting-point of all the so-called "coal-tar" colours. It was because benzene was first obtained from the coal tar, converted into nitro-benzene, and this latter to aniline, $C_6H_5NH_2$, that the term was applied.

Aniline may be regarded as a derivative of ammonia, by the substitution of a phenyl radicle for one of the hydrogen atoms. Organic bodies of this type are known as "amines," and the systematic name for aniline would be phenyl amine. Further substitution may take place to give such bodies as diphenylamine $(C_6H_5)_2NH$, and triphenylamine $(C_6H_5)_3N$, each of which is the basis of a series of dyes.

In the aliphatic compounds also, we have a large number of amines which may be similarly looked upon as substituted ammonias, *e.g.* methylamine, CH_3NH_2, dimethylamine, $(CH_3)NH$, and trimethylamine, $(CH_3)_3N$. It is this latter body which is the chief constituent of herring-brine —possessing the characteristic fish-like smell. The amines are strongly basic, and will form stable crystalline salts with acids, showing their resemblance to ammonia.

In the majority of the dyes it is found that the free base is a colourless compound. The addition of an acid, however, causes the salt to be formed, which is frequently a highly-coloured product. This fact finds application in the working of many of these dyes, the formation of the actual colouring matter, by conversion of the base into the salt, being left to quite a late stage in the operation.

The so-called "coal tar" colours, then, are substituted products of aniline. The two hydrogen atoms in the amino (NH_2) group are replaced by molecular radicles, which are of a greater or less complex nature. The shades and tints of the dye are dependent upon certain groups being present, and by the combination and replacement of different organic radicles, practically any desired colour can be obtained. At the present time the synthetic preparation of dyes of every possible shade of colour is a strictly scientific operation. The exact relation of the groups one to another is known, and instead of haphazard empirical attempts, proper quantitative substitutions are employed. The very close connection between the chemical constitution and the colour of compounds has been worked out to a very high state of efficiency.

Chemistry and Medicine.—In the relationship of chemistry to medicine also we see what valuable results have been obtained by the careful study of the action of different groupings. Quinine, obtained from the cinchona (Peru) bark, has long been known for its medicinal properties, especially in the case of fever. Now examination of quinine showed the presence of certain molecular radicles which it was thought had special reactions upon the body.

Various decomposition products of quinine were tried, and a good knowledge of the particular function of each group was obtained. Experiments to synthesise certain drugs which would have similar physiological reactions resulted in the preparation of phenacetin and antipyrine, which are two of the most valuable febrifuges used at the present time.

A word here must be said of the splendid work of Professor Ehrlich. He discovered that many constitutional diseases, which were the result of micro-organisms in the blood, could be checked and modified by application of certain compounds. This was due to the attraction of certain molecular groupings for these microbes to which they attached themselves. By introducing into another part of the molecule a toxic grouping, the coupling up of the organism and the drug would result in the destruction of the former. Ehrlich turned his attention particularly to the syphilis organism, and after working with 605 compounds unsuccessfully, he prepared the well-known "606," or "salvarsan," which produced such remarkable curative results. Most of the substances he worked with were coloured compounds containing nitrogen grouped as (N : N), and known as the azo group. This is the coupling part of the molecule, and by replacing the colour part with various toxic radicles, he at last discovered the required compound.

Some little insight perhaps has now been obtained of the value of organic chemistry to humanity. This section has been of the briefest nature, and is not an attempt to summarise the whole subject. Only a few of the types of compounds have been given, but sufficient, it is hoped, to give the reader some slight knowledge of the methods and aims of this branch of chemistry.

Radium.—The most recent development of modern science is undoubtedly the phenomena attached to the discovery of radium by Mme. Curie in 1898.

In 1895 the "Röntgen" or "X" Rays were discovered by "Röntgen," and these rays were found to be possessed of remarkable penetrative properties. Thus many bodies which were opaque to ordinary light rays allowed these "X" rays to pass right through. Wood, paper, flesh, aluminium, and light metals are more or less transparent to these rays, whereas heavier metals are more opaque according to increase in density. The well-known application to

surgery of this fact is made use of for the detection of splintered bones or embedded metallic objects. The shadow cast on a screen by the flesh is very feeble, that of the bones much stronger, while a metallic object usually gives a perfect shadow, enabling the distinction to be made at once.

Now the "Röntgen" rays are only one of a number of rays produced when an electric discharge is passed through a tube containing a very highly rarefied gas. The glow which is seen along the inside of the tube is due to a stream of particles carrying negative electric charges shot off from the cathode (negative electrode). These "cathode" rays cause the end of the tube to become phosphorescent, and also strongly heated, owing to the bombardment of these tiny particles which travel with enormous velocity. It is the sudden stoppage of these rays—usually by platinum, which produces the Röntgen rays. By placing an aluminium window at the end of the tube, rays penetrate and are then known as Lenard Rays, which disperse into the air.

All these rays have the power to cause certain substances—*e.g.* zinc blende—to appear luminous in the dark (phosphorescence).

In 1896 Becquerel discovered that salts of a metal known as uranium also had the power of exciting phosphorescence, and further caused the "fogging" of a photographic plate in a dark room, even when the plate was wrapped up in two or three sheets of black paper.

Uranium occurs as an oxide chiefly in the rare mineral "pitch blende," which resembles graphite in appearance. About one half of the pitch blende is the uranium oxide, and up to that time had been used as colouring agent commercially.

Mme. Curie began research in her husband's laboratory in Paris to investigate the origin of the "Becquerel" rays. She discovered that the residue, after extraction of the uranium, was much more active in causing phosphorescence. Naturally this was attributed to the presence of a new substance, which was isolated in the form of the bromide by Mme. Curie after much patient labour. Radium was the name given to the new element, of which the bromide and chloride were the purest salts obtainable; but it was not till 1913 that the pure metal itself was isolated. This was found to be a silvery white metal, tarnished quickly, extremely active chemically, and very unstable. The term radium is applied in a general way, however, to any of the salts of radium, as the common property of these is to give out light and heat.

Pure radium salts are most difficult to obtain, and some idea of the difficulty will be obtained when it is stated that from 1 ton of pitch blende about 2 grains of radium are the result of treating with 5 tons of chemicals. This is the yield from the best selected specimens of the mineral.

Radio-activity.—In addition to giving out heat, radium is continually emitting "rays" which themselves are invisible, but cause "fluorescent" substances like zinc blende to become luminous.

These rays cause glass and other substances to be coloured violet or brown, gases to become conductors of electricity, and the collapse of the leaves of a gold-leaf electroscope. This latter instrument is used by physicists to detect and measure the amounts of small electrical charges possessed by bodies, and forms a valuable means of estimating the quantity of radium in a specimen. A very interesting example of the value of the electroscope was seen when a tube of radium was accidentally lost at one of the hospitals. Certain facts showed that probably it had been thrown into the dust-bin, which in turn had been emptied into the dust-cart. By bringing the gold-leaf electroscope near to the cart, the instant discharge as seen by the collapse of the divergent gold leaves revealed the presence of the radium. The tube was rescued safely from the refuse, and thus radium to the value of £1000 preserved from loss.

A tube containing a radium salt held before the closed eyes, causes the retina to became phosphorescent, and the person is conscious of the sensation of light. Chemically too, the rays are very active, causing the conversion of oxygen to ozone, yellow phosphorus into the red variety, and other similar changes.

The rays emitted by radium are of three kinds, termed the alpha (α), beta (β), and gamma (γ) respectively. Difference towards the action of a magnet is seen with each kind. The alpha rays are slightly repelled from the magnet, the beta rays are strongly attracted, and the gamma rays are not deflected at all.

The alpha rays are solid particles shot off from the radium at the rate of 10,000,000,000 per second from one grain of the bromide. They constitute about 99 per cent. of the total energy, and are positively charged with electricity. Ramsay and Soddy have shown that a real transmutation into helium occurs when these rays are given off in a closed tube.

The beta rays are also solid particles—units of electricity—which travel with nearly the same velocity as light—170,000 miles per second. They have considerable penetrative power, and will pass through a quarter of an inch of lead.

The gamma rays are the most penetrating of any, however, and are the active rays which are so valuable in fighting disease. In many ways they are similar to Röntgen rays, and will pass right through the human body without any appreciable lessening in power. Inches of lead and even feet of iron will not stop their progress, while a photographic plate is fogged after they have passed through six inches of granite.

Radium emanation is another product of decomposition of radium atoms, and is a luminous gas which is obtained from all radium salts in solution. This emanation is very unstable, and its activity is decreased to about one-half in four days. One product of decomposition is the "active deposit" which gives off alpha, beta, and gamma rays itself.

Recently it has been found very advantageous to use this emanation pumped off from the radium in small tubes. Thus there is no fear of losing the radium, and the tubes can be refilled after use.

Radium and Disease.—Great caution has to be used in the application of radium to disease on account of the extreme penetration of the gamma rays. These produce painful irritation and blisters, and often metal screens have to be used to protect other parts of the body. At one time it was thought that only the gamma rays were effectual in curing certain diseases, but it has been proved that the beta rays often have more effect than the gamma rays. It would appear that often the action is selective, according to the particular disease.

Generally speaking, the action of radium seems to be that of destroying or altering the diseased cells, while no effect is produced on normal healthy cells so long as an overdose is avoided.

However, like so many drugs and medicines used for specific diseases, excess will produce the same symptoms as the disease itself on healthy tissues.

The amazing curative properties of radium at first led to wild speculations as to its power in curing that malignant disease, cancer. So far these have not been justified, but many other minor diseases have been quickly and effectively cured.

In the majority of cases of chronic eczema treated, a complete cure has been brought about, and rodent ulcer is quite successfully removed if treatment is applied in time.

Undoubtedly we are on the threshold of a new era in the treatment of disease, and at present the possibilities of radium are immense. It is imperative that the methods of obtaining radium should be improved to such an extent that more extensive experiments can be made, Here again it devolves upon the chemist to apply his knowledge so that humanity may benefit, and that the treatment of disease by radium be much more widespread than at present.

Transmutation.—The wonderful and manifold changes which are associated with radium and other radio-active bodies, again revive the dreams of the alchemists. At the outset it may be stated that there is ample proof to show that one element has been obtained from others. If radium itself is an element—and there seems now little evidence to doubt it—we have a number of different products which are the progressive decomposition or disintegrations of its atoms. The emanation obtained, which was termed by Ramsay "niton," kept in a closed tube, quickly disintegrates. The chief product is helium, but we have also other products. The first was named "radium A" by Soddy and Rutherford, who discovered that it was formed by the loss of alpha particles. "Radium B" was the next product obtained from "radium A," and this was caused by loss of beta particles or electrons. Progressive decomposition into "radium C," and this into "radium D," was the result of further loss of alpha particles.

Naturally, during all these successive disintegrations there is loss of energy which corresponds to the extent of the change.

As far as we can judge, "niton" itself is an element. The change of one atom of niton into three atoms of helium—itself an element, would prove conclusively the transformation of one element into another. Further confirmation, however, is obtained by the fact that other bodies which are "radio-active," such as thorium and actinium, give off similar emanations which disintegrate into helium.

Niton itself is an intensely powerful transforming agent, and very interesting results have been obtained from its use. Thus it seems as though under the influence of its energy, that copper could be transmuted to lithium.

For this purpose copper sulphate, $CuSO_4$, was used which had been subjected to many purifications and crystallisations. Separate samples of this absolutely pure salt were put into similar glass bulbs. One was charged with niton for a month and then sealed, while the blank was sealed without any further addition. The contents of the bulb charged with niton showed distinctly the presence of lithium, by means of the spectroscope. Lithium had been previously tested for in the glass itself, and was found absent. To make sure that it was not from the glass under the influence of niton, a further test was made with the glass so treated, and again with negative results. Finally, the bulbs were made of silica in place of glass, with the result that tests for lithium revealed its presence only in the solutions treated with niton, and never in the control experiments with the blanks.

Thorium Emanation.—More remarkable results even than these were obtained from the emanation obtained from thorium salts. It has been stated that, like radium, thorium salts yield an emanation which disintegrates into helium. The time for this transformation is much longer, and it was in an experiment to see if helium really was produced that the following facts occurred. An aqueous solution of thorium nitrate in a hermetically-sealed vessel,

carefully pumped air-free, was left for six months. Analysis of the gas pumped off was then made, and showed the presence of carbon dioxide, nitrogen, oxygen, and hydrogen. Keeping further for six months showed a great increase in the amount of carbon dioxide, with traces of helium. Many repetitions gave exactly the same results, whereas in the control blank experiments an inappreciable amount of carbon dioxide was found. When niton was allowed to act upon thorium nitrate, carbon dioxide was always formed. Some other members of the same family as thorium—namely silica, titanium, zirconium—in various compounds, gave carbon dioxide when acted on by niton.

These are some of a number of experiments which have been done either by, or under the direction of Sir William Ramsay. Surely from such evidence as this it may be safely concluded that a real case has been made out for the transmutation of the elements.

General considerations of the chemical properties of the compounds of the elements would seem to show that the higher the molecular weight, the greater the instability of the compound. The fact also that energy is given out in the formation of the majority of compounds is known because of the heat liberated during the reaction. Hence in such exothermic reactions the elements unite with less of energy.

An analogous case would seem to exist with the elements themselves, *i.e.* increase in atomic weight, as a general rule, means decrease in stability—that the higher the atomic weight, the more rapid will be the disintegration of the atoms. As Ramsay points out, however, the analogy is only a very general one. Niton, radium, and thorium placed thus are in the order of increase of atomic weight, but are inversely as regards stability.

It does seem certain, however, that all the substances which exhibit radio-activity are chemical elements in varying conditions of instability. Further, all of these substances have their own particular rate of decay. The half-life period, of radium for example, is nearly 2000 years. This means that in 2000 years' time the activity and energy of the radium will be reduced by one-half of what it is at present. A further period of 2000 years will again diminish its energy by one half, and so on. Of course, for practical purposes we may assume that the disintegration of radium is so slow that it is negligible. This has given prevalence to the popular idea that radium is absolutely inexhaustible.. It is true that we may go on pumping off the emanation thousands and thousands of times without any apparent diminution in the activity of the salt. But the disintegration is going along very slowly, and although the radium seems to recover its full energy after a short time, yet the real activity has been slightly if inappreciably diminished.

In conclusion, we may as well briefly consider some very interesting ideas as to the evolution of the elements. To better understand the theories put forward, it is necessary to have a more or less close acquaintance with the spectroscope or spectrometer. This instrument has been one of the most valuable assets of the chemist and physicist. Helium was first discovered in the sun by means of the spectroscope —hence its name (*helios*=sun), and it was not until later that it was found in "cleveite" gases on the earth.

Evolution of the Elements.—When a gas is heated to a sufficiently high temperature, it emits a glow, and produces the sensation of light upon the retina. Now the sun consists of a huge mass of incandescent gases, which are at a tremendously high temperature. All those gases emit light of different colours, and the combination of all these colours gives rise to white light. That this is so is seen when a beam of sunlight is passed through a glass prism, and we get a number of different-coloured rays. The rays of light are bent through the prism, and if a screen is interposed, we obtain a coloured band of light known as the spectrum. These colours extend from red to violet, through the intermediate colours of orange, yellow, green, blue, and indigo. The bending or refraction of the light is least with the red, and greatest with the violet rays.

The best effect is produced if the beam of light is passed through a narrow slit before it reaches the prism. In the spectroscope the light passes through such a slit in the "collimator" tube, thence through the prism, and is viewed through a telescope. All three of these essential things of the spectroscope—collimator, prism, and telescope—can be rotated, so that suitable adjustments can be made.

If now a Bunsen flame is placed at the end of the collimator, and a small piece of metallic sodium burnt on a platinum wire, the flame is coloured yellow, and on looking through the telescope a yellow line is seen. Similarly, sodium chloride (common salt) will give the same effect, owing to the decomposition of the salt and the incandescence of the sodium vapour. With a good spectrometer which contains a powerful telescope, there will be seen two yellow lines very close together, and which appear as the one line on an instrument of less power.

In the same way certain other salts which can be decomposed by the flame, will give different-coloured lines in different parts of the spectrum. Every element has its own particular spectral line or lines, and it is thus that we can identify elements by means of the spectroscope.

Now light is the effect produced by vibrations of that all-pervading medium—the ether. We know very little of this ether, but it is certain that when we "see" light our eyes receive the waves

of the ether of space. The fact of different-coloured rays is due to different vibrations of these waves. An analogous case is with sound waves, which are vibrations of columns of air. Now, the more vibrations per second, the higher the pitch of the note produced, and *vice versa.* If the vibrations become too slow, the note produced is so low that our ears are not sensitive enough to perceive it. The greater the number of vibrations in a given time, the higher the note, and although we can hear some very shrill tones, yet there is a stage beyond which we cannot detect any sound—the vibrations are so fast. Similarly with the light waves; there are vibrations which do not affect the eye, and we have an invisible spectrum which extends beyond the red (infra-red) on the one side, and beyond the violet (ultra-violet) on the other. There are rays which, in the case of the "infra" red, are heat rays, and can be detected by instruments delicate enough to show very small changes in temperature. These heat-rays have a lower vibration than those of the visible spectrum. At the other end of the spectrum we have the "ultra" violet rays, which neither give out heat nor are visible, but are capable of producing certain chemical changes. These very active rays have a much higher vibration than even the violet rays of the visible spectrum, and blacken "sensitised" paper, and cause many substances to appear phosphorescent.

Fraunhofer's Lines.—When the solar spectrum is examined very closely by means of a good spectroscope, it is seen to be crossed by a great number of dark lines. These lines were first discovered by Fraunhofer, and look just as though a number of wires had been stretched across the beam after it has left the prism, thus projecting their shadows on the screen.

These dark lines evidently indicate a diminished intensity of light, and investigation showed that this was due to absorption of waves of certain vibration numbers. In order to prove this, we first obtain a continuous spectrum of the light from an arc lamp. The spectrum of sodium, as obtained by placing a wire with sodium chloride in a Bunsen flame, is then interposed between the source of light and the spectroscope. On looking through the spectroscope, a dark band is seen where the yellow sodium line should be, showing that the waves of light having the vibration of the sodium line have been absorbed in passing through the incandescent sodium vapour.

In the same way interposition of other salts resulted in the production of dark lines in the place of the characteristic coloured lines of the element. Of course the light from the arc-lamp alone gives a pure continuous spectrum, with no dark lines, because there are no gases for the light to pass through and to be absorbed.

This is further confirmed by the fact that there is an increase in the number of lines when the sun is low in the sky, owing to the increase in the amount of hot gases through which the rays have to pass. As ordinarily seen, these lines are quite irregular—some broader than others, and in places they are crowded closely together, while in other parts of the spectrum they are separated by relatively wide spaces.

Absorption of certain rays may be produced by interposing certain coloured glasses, solutions, &c. Thus red glass will cut out all rays but red; blue glass will stop all but the red and blue; a dilute solution of potassium permanganate will selectively absorb certain rays, and give dark lines in the green part of the spectrum.

Now the same elements will often give different spectra at different temperatures. The commonest way of obtaining spectra is to heat salts in a Bunsen flame. If the heat obtained in the arc lamp is utilised, the temperature is much higher, and a somewhat different spectrum results. A further change may be produced by using the spark discharge from an induction coil. With many elements it is found that certain lines in the particular spectrum are enhanced and stand out more prominently. This is explained by the fact that at lower temperatures the spectrum is that of the molecules, and rise of temperature breaks up the molecule into the component atoms, and thus the spectrum at the higher temperatures is that of these atoms. Such considerations as this give us much valuable information as to the formation, composition, and temperature of many of the heavenly bodies.

Spectra of the Stars.—Sir Norman Lockyer did much to further our knowledge of the spectra of the stars. In his examination of the stars he classified them according to their temperature. The hotter the stars, the farther did the spectrum extend into the ultra-violet region. The spectrum of a heated body changes gradually on rise of temperature right through from the red to the violet. A very common illustration of this is seen when a poker is heated. It first gets "red hot," then changes through yellow to a white-hot stage, which is due to the fact that there is a mixture of all the spectral colours. This, of course, is the state of affairs in ordinary sunlight, and hence the increase in temperature proves increase in ultra-violet rays.

The basis of Lockyer's grouping of the stars was the enhanced lines of the common elements which thus indicated the different stages of temperature. Now many of the stars are infinitely hotter than the sun, and the hotter the star, the fewer elements does it contain according to the spectroscope. These stars with the higher temperature consist chiefly of the gases hydrogen and helium, together with elements having certain unknown spectra. At a lower stage we get the spectra of oxygen,

nitrogen, and carbon, and further lines which have not yet been identified; and so on as we descend the scale. In Lockyer's words: "As we come down from the hottest stars to the cooler ones, the number of spectral lines increases, and with the number of lines, the number of chemical elements. In the hottest stars of all, we deal with a form of hydrogen which we do not know anything about here (but which we suppose to be due to the presence of a very high temperature), hydrogen as we know it, the cleveite gases (helium), and magnesium and calcium in forms which are difficult to get here; we think we got them by using the highest temperatures available in our laboratories. In the stars of the next lower temperature, we find the existence of these substances continued in addition to the introduction of oxygen, nitrogen, and carbon. In the next cooler stars we find silicon added; in the next we note the forms of iron, titanium, copper, and manganese, which we can produce at the very highest temperature of our laboratories; and it is only when we come to stars much cooler that we find the ordinary indications of iron, calcium, and manganese and other metals. All these, therefore, seem to be forms produced by the running down of temperature. As certain new forms are introduced at each stage, so certain old forms disappear."

Hence a decrease in the temperature of the planetary systems results in a process of atom-building, and it is here that we must turn for the theories regarding the evolution of the elements. It is probable that originally, at a temperature even higher than that of the hottest stars, there is one primordial element. This is possibly of some such nature as the hydrogen which Lockyer describes as hydrogen "which we know nothing about." Millions upon millions of tiny particles of such a substance would be shot off in all directions constantly, and as they cooled would unite in various glomerations. The different ways in which these aggregations formed would be distinguished by different properties of the atoms of what we call the elements.

Ideas such as these have much in their favour, and if all matter has been formed from some one primordial element, then there is the strongest reason to suppose that somewhat of a reverse change can occur—namely, the conversion of one element into another.

COURSE OF READING

History of Chemistry.—In pursuing a course of reading in chemistry, it will be found better to postpone anything like a complete study of the History of Chemistry till a further general knowledge of the science has been obtained. This will be found to help to a much better understanding of the ideas and conceptions of the philosophers of past centuries. Although to read the slow progress and development of the science is very interesting, yet a fairly close knowledge of chemistry as it is to-day is required to enable us to appreciate the difficulties, and understand the errors of the past. Hence I would recommend that any systematic study of history of chemistry be postponed till a later stage. It may not be out of place here, however, to indicate one or two suitable books. Many books dealing with this part of the subject are dull and heavy, and provide but little stimulus for further reading. *Alchemy, Ancient and Modern*, by H. Stanley Redgrove, published by Rider & Son, will be found to be a very good introduction. About three-fifths of the book is devoted to a most interesting and lucid account of the alchemists and their doctrines, and their influence generally on the science. The rest of the book is taken up with two chapters, "The Age of Modern Chemistry," and "Modern Alchemy," and these deal with some of the most recent advancements of the science.

The two small volumes by Sir Edward Thorpe, *History of Chemistry*, published by Watts & Co., are of a biographical nature and can be thoroughly recommended.

Then of a different style and more advanced nature is the classical *History* by Ladenburg, which nevertheless is of a very readable and interesting character. Finally, a more modern work by Armitage of a similar type, is a work to be studied with advantage by those seeking further information.

Inorganic Chemistry.—In this article a minimum of laws and theories has been dealt with. This is because a good general idea as to the compositions of substances and their reactions is best for the easier assimilation of such theories. At the same time, however, it is advisable to obtain a good grasp of the fundamental principles as soon as a familiar knowledge of the commonest chemical facts is grasped. For this purpose it is really necessary that something in the way of practical work should be done, and this will be treated later.

There are many so-called "popular" works on chemistry. Some are so elementary, and the extravagantly simple style so laboured, that the ordinary man gets impatient. On the other hand, some are so advanced and technical in their treatment, that the book is really little more than a compressed edition of the usual text-book.

Before proceeding to the more thorough treatment of chemistry, the following books may be mentioned as amplifying the article, and also extending the elementary principles: *Inorganic Chemistry*, by Baly, in "The People's Books," 6*d*. (Jack); *Chemistry*, by R. Meldola, 1*s*.

Then there are two small volumes by M. M.

Pattison Muir, which, although not so recent as the above, are very concise and original in style. They are *The Story of the Chemical Elements*, and *The Wanderings of Atoms*, and are published by George Newnes in the Library of Useful Stories.

A systematic course might now well be followed by means of elementary text-books. Brief mention has been made in the article of the Periodic System, and this generally forms the basis of study. In most books there is usually an introduction, which is then followed by consideration of some of the commoner elements—hydrogen, oxygen, nitrogen, and carbon, with their most characteristic and well-known compounds. The further study of non-metals in their "families" is usually the next procedure, and then the metals and their compounds in the same way.

This customary treatment is really quite sound, as in a proper study of chemistry it is essential to have a well-defined system throughout. And what better system could be adopted than that of the natural groups of elements as regards their properties and those of their compounds ?

Walker's *Inorganic Chemistry*, published by Bell, is a small text-book which is well written and of an elementary nature.

Inorganic Chemistry in two parts, by Kipping and Perkin, is one of the most recent texts. The treatment is thoroughly original and progressive, and the fundamental principles receive proper consideration in the right place. Then, too, the essentials of physical chemistry are given which are necessary to supplement the inorganic side. The first part of Newth's *Inorganic Chemistry* is also quite good in this respect, although the book as a whole is for examination purposes, and is really only suitable for detailed study later.

Inorganic Chemistry, by Shenstone, is a good example of the incorporation of practical exercises with the theory of chemistry.

By the same author also is a work *The New Physics and Chemistry*, which is a collection of popular essays which will be found to be a very clear exposition of the methods of modern chemistry and physics. *The New Chemistry, Weighing a World, Weighing Atoms, The Mechanics of Chemical Change*, are some of those very excellent lectures.

The above will be found to be a general course of reading in inorganic chemistry, sufficient to enable the student to obtain a thorough grasp of this branch of chemistry.

Special subjects which have been dealt with in the article can be further studied in the following: *The Spectroscope and its Work*, by Newall, under the series of Manuals of Elementary Science, published by the S.P.C.K., is a very good and complete account of the methods and value of this instrument in chemistry. The the same publishers have a splendid work on *Radium and Radio-activity*, by H. T. Cameron, in the Romance of Science Series. This is very recent (1912), and gives an excellent account of radium and associated elements in their varied aspects.

In the *New Physics and Chemistry*, by Shenstone (referred to above), there are two very good essays on "Radium" and "Radio-active Change" which serve as an introduction to further study.

The Periodic Law, by A. E. Garrett, in the "International Science Series," forms a complete survey of this fundamental basis of modern chemistry.

Organic Chemistry.—With regard to organic chemistry, it is not advisable to attempt anything like a detailed study until a good foundation in inorganic chemistry has been laid. Indeed, such an attempt must end in disappointment, as it is essential that a thorough knowledge of the principles of the science be obtained.

An introductory book is Cohen's *Organic Chemistry*, in "The People's Books," *6d.* (Jack), and this might well be followed by the *Organic Chemistry* of Perkin and Kipping, Parts I. and II. This latter is a good general work, as is also the *Advanced Organic Chemistry* by Cohen, which is of a similar type.

A splendid book of an entirely different nature from the orthodox text-book is seen in *Modern Organic Chemistry*, by C. A. Keane, and published in the "Contemporary Science Series." This work is very original in its lucid treatment, and shows very clearly the close connection between chemistry and the affairs of daily life. The concluding chapter, on "Physiologically Active Compounds," is intensely interesting, and gives some insight into the methods of chemistry as applied to medicine.

Practical Work.—The question of practical work may be briefly considered here. Much interesting and instructive study can be obtained by reading chemistry, yet, as has been intimated before, chemistry is essentially a practical science. As such, practical work must be done, if anything like a complete grasp of the subject is wanted.

The following practical hints are not intended to be anything like complete. The aim is merely to illustrate the subject-matter of the article, and by this co-ordination to intensify the interest of the reader for further study.

The experiments can be done with the simplest and most inexpensive of apparatus. Still, as some few things are necessary, an outfit such as supplied by Messrs. Griffin, Kingsway, London, W.C.

The cheapest is *16s.*, which contains the chief reagents and preparations in addition to the apparatus. Of course, other firms supply similarly, and special pieces of apparatus can be obtained from time to time. It is very de-

sirable however, that some kind of outfit be supplied at the start.

The action of heat upon calcium carbonate (chalk), to change it to calcium oxide or quicklime, may be first tried. The difference in the product is seen in the action of water; the chalk is apparently unchanged, while the quicklime "slakes" to form slaked lime $Ca(OH)_2$.

By fitting a cork with a delivery tube into a tube and heating the chalk in the tube, the gas given off during the heating may be collected in a gas jar. As it is a heavy gas, simply leading it to the bottom of the jar will replace the air with the carbon dioxide. The heaviness may be demonstrated by pouring the gas into a beaker supported on one arm of a balance. The action of the gas upon a lighted taper, and the behaviour of a solution of the gas in water, may be studied. The gas is much more conveniently prepared by acting upon chalk or marble with dilute acids.

The approximate composition of the air by volume may be seen by burning a piece of phosphorus in a closed vessel inverted in a bowl of water. If the space in the vessel above the water be divided up in five divisions by marks on the vessel, the water will be found to rise to one of these divisions, showing that oxygen constitutes one-fifth of the atmosphere. The gas remaining in the jar may be tested for nitrogen by means of a lighted taper. A further supply of nitrogen may be obtained by passing a slow current of air over copper heated in a tube, and collecting the resulting gas in cylinders over water. This may be done by fitting a two-holed cork into a flask; through one of these holes is fitted a thistle funnel reaching to the bottom of the flask; through the other a tube leading into the horizontal tube containing the pieces of copper. After the copper is red-hot by means of the spirit-lamp or Bunsen flame water is slowly dropped into the funnel from the tap, and this forces a stream of air over the copper. The oxygen is removed to form copper oxide, and the nitrogen passes on and may be collected.

Oxygen.—The preparation of oxygen can be easily done by simply heating many substances rich in oxygen, such as mercuric oxide, red lead, &c. To collect one or two cylinders of the gas, a mixture of potassium chlorate and manganese dioxide is heated in a test-tube clasped horizontally, with a delivery tube leading under water as in the collection of nitrogen. Four or five jars of the gas should be collected, and the effects of burning fragments of sulphur, carbon, phosphorus, sodium, and potassium noted: the increased vigour of the combination of the oxygen and the substances being indicated by the additional brilliance of the combination. The products of the combustion should be then dissolved by shaking with a little water, and the action upon litmus of the resulting solutions observed.

A few experiments with different kinds of water will prove instructive at this point. Ordinary tap water is generally a good example of a hard water. It may be tested by shaking with a small quantity of soap solution, when practically no lather will be obtained—only curdy flakes. By boiling tap water for some time and thus expelling the carbon dioxide, the calcium carbonate will be thrown out of solution. The water will have been softened from its temporary hardness, and shaking a quantity with soap solution will now readily produce a lather. The water may also be softened by the addition of lime water—an example of Clark's process. In order to understand the changes, a very hard water is made by adding lime water to tap water. Carbon dioxide is then bubbled through, when a white cloudiness will speedily appear. This is due to the precipitation of calcium carbonate. On continuing to pass the carbon dioxide through the solution, it gets quite clear again, showing how it is possible for the water containing carbon dioxide to dissolve calcium carbonate.

The difference in the actions of hard and soft waters upon lead pipes is seen by putting a bright strip of lead foil into each of two stoppered bottles, one containing a hard, and the other a soft water. After leaving a few days, the lead in the soft water usually acquires a coating of the oxide due to the dissolved air, and this dissolves in the water if much carbon dioxide is present. Lead may be tested for by adding a few drops of sulphuretted hydrogen solution, when a brownish tinge, or even a slight precipitate, will appear in the case of the soft water. The hard water, containing practically no lead, will not show any such characteristic action.

Water of Crystallisation.—Observe the gradual change in a clean crystal of washing soda ($Na_2CO_3 \cdot 7H_2O$). It becomes coated with a white powder, and if kept exposed in a dry place for some time will entirely change into a powder. The same change will be much more quickly brought about by heating the sodium carbonate. It is due to the loss of the contained water of crystallisation.

Similarly, by heating crystals of blue vitriol ($CuSO_4 \cdot 5H_2O$) a white powder is obtained ($CuSO_4 \cdot H_2O$), as four of the molecules of water have been driven off. The restoration of the blue colour when water is added indicates the taking up again of these four molecules.

A weak solution made by dissolving a fragment of cobalt chloride ($CoCl_2 \cdot H_2O$) in water may be used as a sympathetic ink. When dry, the characters are practically invisible—especially on unglazed paper—but on warming they stand out as a distinctive blue owing to the expulsion of the water of crystallisation. On

allowing to stand in the air, moisture will slowly be taken up, and the invisible characters will form again.

Oxides.—The fact that sulphur burns in air and oxygen to give sulphur dioxide (SO_2) has been shown already. Further, in the acid action of a solution of this gas in water, we have observed a characteristic property of most of the oxides of the non-metals. Similarly with the burning of carbon to form carbon dioxide —also acid in its reaction.

One of the commonest of the five oxides of nitrogen is obtained by the action of strong nitric acid upon copper. These brown fumes of the nitrogen peroxide (NO_2) may also be obtained by heating the nitrates of the heavy metals, *e.g.* lead nitrate ($Pb(NO_3)_2$). The solution of these brown fumes in water show an acid reaction.

The burning of many metals gives us basic oxides, as shown by the formation of the oxides of sodium, potassium, zinc, and magnesium. The two former are readily soluble in water to give alkaline solutions; magnesium is slightly soluble, but oxide of zinc, ZnO, is practically insoluble. A solution of the oxide of calcium, CaO, in water is of course alkaline, but much milder in its action than the hydroxides of sodium and potassium, which are termed "caustic."

Common Acids.—The preparation of hydrochloric acid is easily done, but care must be taken, as the fumes are of a disagreeable and choking nature. A flask fitted with a double-holed cork is used, and a thistle funnel reaching to the bottom of the flask. Sodium chloride, $NaCl$, is placed in the flask, and strong sulphuric acid added gradually through the tap funnel. A rapid stream of the gas is evolved which will be rapidly absorbed in water to give a strongly acid solution. A jar of the gas may be obtained by the downward displacement of air. If a jar of ammonia gas be brought over the top of the jar, dense white fumes will form of ammonium chloride:

$$\underset{\text{Ammonia}}{NH_3} + \underset{\text{Hydrochloric acid}}{HCl} = \underset{\text{Ammonium chloride}}{NH_4Cl}$$

This is one of the simplest examples of the formation of salts from acids and bases.

Potassium chloride and sodium chloride may also be obtained by adding hydrochloric acid solution to caustic potash solution, KOH, or caustic soda solution, $NaOH$, until very slightly acid, as shown by a litmus paper.

Concentration of the solutions by evaporation and allowing them to stand and cool, will give crystalline specimens of the salts. These may be pressed on a piece of porous unglazed pot, and finally dried by means of absorbent filter papers.

The action of concentrated and dilute hydrochloric acid should be tried on fragments of magnesium, zinc, iron, lead, copper, and tin. Examine any gases that may be evolved, and see if heating affects the reaction.

Nitric Acid, HNO_3.—This acid is easily prepared by heating sodium nitrate, $NaNO_3$, and strong sulphuric acid, H_2SO_4, in a glass retort. The salt first dissolves in the acid, and then as the temperature is raised, the nitric acid distils over and should be collected in a large flask as receiver. Owing to the slight decomposition of the acid by heat, the product will be coloured yellow, due to the presence of nitrogen peroxide, NO_2.

$$\underset{\substack{\text{Sodium}\\\text{nitrate}}}{NaNO_3} + \underset{\substack{\text{Sulphuric}\\\text{acid}}}{H_2SO_4} = \underset{\substack{\text{Sodium hydrogen}\\\text{sulphate}}}{NaHSO_4} + \underset{\substack{\text{Nitric}\\\text{acid.}}}{HNO_3}$$

Nitric acid will be found to be powerfully corrosive, and generally speaking reacts much more vigorously than hydrochloric acid. Investigation of the action of weak and strong acids upon the common metals should be made, as in the case of the hydrochloric acid. Typical salts, such as sodium, potassium, and ammonium nitrates, should be prepared by neutralisation and concentration.

Sulphuric Acid, H_2SO_4.—This acid cannot be conveniently prepared on the small scale, but its reactions upon metals may be done. The fact that sulphuric acid is "dibasic"—*i.e.* that both the hydrogen atoms may be replaced by metals—can be easily shown. Potassium hydroxide solution is just neutralised with dilute acid, and the resulting solution of normal potassium sulphate, K_2SO_4, evaporated and crystals obtained.

Then to a similar amount of alkali, roughly twice the quantity of acid is added, and the potassium hydrogen sulphate, $KHSO_4$, obtained by concentrating the solution.

The two reactions may be represented side by side:

$$\text{(i) } \underset{\substack{\text{Potassium hy-}\\\text{droxide}}}{2KOH} + \underset{\substack{\text{Sulphuric}\\\text{acid}}}{H_2SO_4} = \underset{\substack{\text{Potassium}\\\text{sulphate}}}{K_2SO_4} + \underset{\text{Water}}{H_2O}$$

In the second experiment we have used only one-half of the quantity of alkali:

$$\text{(ii) } \underset{\substack{\text{Potassium hy-}\\\text{droxide}}}{KOH} + \underset{\substack{\text{Sulphuric}\\\text{acid}}}{H_2SO_4} = \underset{\substack{\text{Potassium}\\\text{hydrogen sulphate}}}{KHSO_4} + \underset{\text{Water}}{H_2O}$$

The two sets of crystals will be found to be of different crystalline form. If dissolved in water, the normal potassium sulphate will be found to be neutral to litmus, whereas the potassium hydrogen sulphate will turn blue litmus red.

Preparations of different salts of this nature

give a very good idea of the relationship between acids, bases, and salts.

The above practical experiments are a few of the many which can be done easily with simple apparatus. Those who find their interest stimulated for further work would do well to work through *A Safe Course of Experimental Chemistry*, issued by the University Tutorial Press. By the time this excellent little book has been worked through, the student will find himself in a position to tackle the subject from a more detailed and serious standpoint. Shenstone's *Inorganic Chemistry* may then be recommended as providing a more or less complete elementary course, incorporating theory with practice.

H. LAMBOURNE.

VIII. PHYSICAL-BIOLOGICAL SCIENCE

GEOGRAPHY

GENERAL PRINCIPLES

Introduction.—Geography, broadly speaking, is the science of the earth as the home of man. Its claim to rank as a science has been disputed, and indeed still is; but this position is becoming steadily more untenable. It is not an ultimate or fundamental science, such as mathematics. Nor is it independent of the other sciences. It levies toll of many—mathematics, geology, biology, physics, and many others; but it looks at these from its own standpoint and uses them in its own way, as, for example, geology uses chemistry, crystallography, dynamics, and the like.

Geography may be looked at in various aspects and treated accordingly. Thus we have mathematical geography, physical geography, economical geography, historical geography. One thing at least is certain, that geography has at last been set free from the trammels of the old topography, which gave the unfortunate learner the task of memorising long lists of names—counties, towns, rivers, mountains, capes, bays, all huddled together in one meaningless confusion. Now each name has to pass a certain scrutiny, and none burden the memory except for some definite purpose, and when the purpose is known and grasped, the burden becomes insignificant. The study has become organised, cause has been related to effect, and the knowledge so acquired has ceased to be the barren thing it once was. Take one example. In the old days one was taught that there was such a thing as the Pennine Chain, that it ran south from the Cheviots into Derbyshire, and that it contained five peaks whose names had to be memorised. Nothing more than this, and this repeated for every mountain system in the British Isles.

Nowadays one learns, though perhaps not in this order, that geology can tell its history, a history not without interest. For it awakens the imagination to know of the deposition of the coal measures, and something more of its history until the land became elevated, and lost by denudation the whole of its coal except the ends to right and left, which are the coal-mines that supply energy to the two great industries of Northern England. One learns of the sheep that are fed on the hill-slopes to supply the wool, and that the mountains provide rivers of soft water for the wool and for water-power; one learns of the rainfall that they provide, and the reason for its being greater to the west; of the humid air that results, and its usefulness for the cotton manufacturer; of the main routes into Scotland, and the obvious reasons for their position; of the passes too that the rivers have worn out across the chain, and the advantage of these for cross communication; one may learn too something of the scenery, and even perhaps the names of the higher peaks as well.

This seems possibly a much larger order than the first, but you must remember that it appeals both to the reason and the imagination of the student, and has given him a vast amount of information that under the old system had to be learned as a set of isolated facts. He will now find that he knows where some coal-fields are, that he knows something of the staple industry of England; the fact that the west coast is, as a rule, wetter than the east will not surprise him; questions of climate and plant distribution have broken ground in his mind; in short, he has been taught geography, and not a list of names.

Local Geography.—Geography begins at home. A great deal of work which will foster the geographical spirit and develop the geographical type of mind can be done within a comparatively small area round your own doors. The work that can be done on local geography, whether indoors or out, is of a varied kind.

The simplest exercise is that of finding direction, the direction of various landmarks, of a river, of a walk, of a road, by means of the different ways at our command. The most important of these is the magnetic compass, but remember that the needle does not point to geographical north, the angle of difference between magnetic and geographical north being

called the declination. Most compasses indicate the declination closely enough, but *Whitaker's Almanack* gives it for a number of years back. Try to establish the habit of keeping various directions fixed in your mind; the deviations in direction of streets or roads in your own vicinity will probably surprise you.

In addition to the compass you ought to be able to find direction by the sun at noon, by the Pole Star, or by using your watch, according to the well-known rule: point the hour hand to the sun; midway between that and XII is due south. Work out for yourself the reason for the rule.

Before you go on to any other outdoor work you will find it practically essential to have an ordnance map of your own district, or preferably two maps, one with a scale of 1 inch to a mile, the other 6 inches to the mile. A great deal of work which can be done with difficulty, if at all, with the one is comparatively simple with the other. If only one can be bought, the 1-inch map is preferable, with contours, and unshaded.

Contours.—The first thing to be done with the map is to study carefully the various symbols used and to verify by actual field work the accuracy of the information conveyed. The understanding of contours, or lines which join all points having the same elevation, is of the utmost importance. A set of closed contours round a hill is possibly the simplest to start with, and ought to be carefully studied. Four exercises may be done with that end in view. (1) Copy out the contour lines of the hill on to a sheet of paper by means of tracing paper. Then colour in varying shades of brown. Make the inside ring, which includes the top, very dark brown; down to the next contour will be lighter, and so on. This gives a very effective impression of height. (2) Copy the contours in pairs on to sheets of cardboard (cardboard boxes are quite satisfactory); if you number the contour lines in order, then the first sheet will have Nos. 1 and 2, the next sheet Nos. 2 and 3, the next 3 and 4, and so on. Cut out the cardboard along the outer of the two contours; then the sheets can be superimposed, so that the hill will stand out in relief. The inner line will show you where to place the layers. To make the hill appear higher, bits of cardboard can be placed between the different layers and fixed with glue. If now the stepwise arrangement is smoothly covered over with clay or plasticine, the effect is extremely natural. (3) Make for yourself with clay or plasticine on a sheet of paper a model, as like the original as you can, of the same hill. Cut it across in a definite direction, and examine the section you have made. The two halves can easily be joined up again and another section drawn afterwards. (4) Draw a section of the hill from the map itself. You don't need to draw an actual line on the map. Lay a strip of paper along the line of section. Mark on it the points where it cuts the contour lines, numbering the contours as you mark them. Transfer these points to a sheet of paper, preferably a ruled sheet for the first attempt, as it saves time. At each point raise a perpendicular, the height to depend on the height of the contour line. Join these points by a continuous line, and the section is made. Try the effect of different rulings. The appearance will be somewhat as shown (Fig. 1).

With a little calculation you can make a section whose vertical and horizontal scales are the same; note how absurdly low the hill appears. Sometimes, when evening has hidden everything but the skyline, you may see your section revealed against the sky.

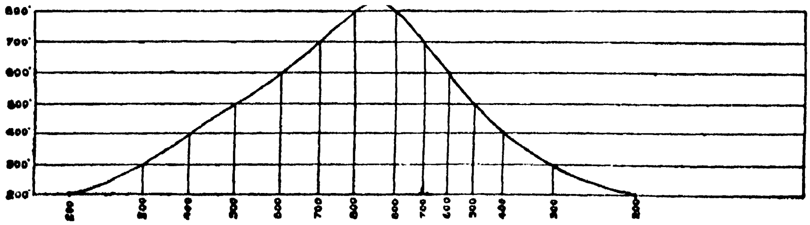


Fig. 1.

Section-drawing is best done on the 6-inch map. In the 1-inch map the scale is too small to give any effect; in that case the whole figure ought to be enlarged to scale.

The work here described can of course be done for a valley or any part of the map, but the making of models need not be attempted for anything complicated.

A useful variant of the section drawing is to show the gradient of a road (turnings may be marked on your section by a T), or the actual slope in going up a hill in a zigzag fashion.

Road, Rail, and River.—You may set yourself a number of other exercises on the map, such as: Find the distance as the crow flies between two prominent points. Find the length of a road by thread measurement, and estimate its character

from a cyclist's point of view, the nature of its surface, its hilliness, or the reverse. In the case of rivers find the length by using a thread. From the rate at which the contour lines are cut tell if it is rapid or the reverse. What is its breadth? Where are the bridges? Account, if you can, for the position of these, for a bridge is not set down at haphazard. Does a road run alongside the river? Examine all the roads and railways to see for yourself how they follow the lines of least resistance. Is there an instance in your map of a road, a river, and a railway running close to each other? If you had to connect two points in your map, choose the easiest route for a road. Why are the points not already connected?

Trace out the parishes, and observe where the boundaries lie. Mark out your own parish in red ink, and calculate its area by using squared tracing paper, or by means of carbon paper transferring it on to squared paper. Find out the total area of your map. Also with a large scale map trace out your county, and find its area. What proportion is your parish of the total county area? What is the general lie of the land in your map? If there are any prominent hills, do they reach approximately the same height? In many parts of the country the hills exhibit a trend, as shown in sketch (Fig. 2).

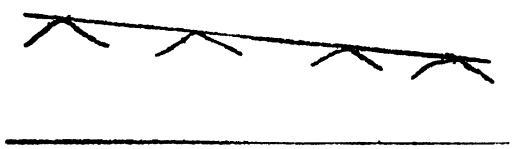


FIG. 2.

Can you find anything corresponding to this in your map? If so, what conclusion can you draw?

Select one of the hills. Mark out the easiest route to climb it. Try to describe from your map the view you would have from its summit, the other hills visible, the character of the land, the rivers, roads, hamlets, &c. Verify your conclusion by actual observation. Describe the appearance of the landscape if fog or mist rose to a height of 300 feet, 400 feet, and the like. What height of mist would be required to make your hill appear an island?

Examine the names of places on your map. How many can you find that show evidence of Celtic, or Scandinavian, or Saxon, or Roman origin? Is there a preponderance of any of these? If so, you have a clue to the history of your district. But remember that the so-called derivation of place-names is often fanciful and inaccurate. What other historical interest does your district contain?

If you have access to statistics from census returns, find the population of your own and surrounding parishes, calculate the population per square mile, and on a tracing of these parishes colour or shade the parishes to show density of population, and also represent by the number of dots in 1-inch squares. If one of the parishes is of outstanding density, how do you account for it?

Can you write across your map the districts under crops, under pasture, mainly devoted to rearing stock, the fruit-growing areas, the manufacturing parts? Account for the division as far as you can.

Examine the shape of your parish and the position of the parish church. It is often found that the parishes are long rectangles with the village containing the parish church situated on a geological formation supplying plenty of water, with poorer land extending for some miles on either side. The villages may then lie near each other in a line, each with its own parish church, and the centre of its own parish life. Is this the case with your own parish? If not, can you account for its shape and extent?

Map-making.—This only gives a general idea of the amount of work that can be done with the local survey maps. You may also find it possible to do something in the way of map-making. The simplest kind of work of this nature is to find first of all the length of your step; then by counting steps along a straight bit of road you can find the distance you have gone; at stated intervals you can find the compass-bearing of churches, houses, hill-tops, &c. Then by a drawing to scale you can make a plan of your own work, which will then appear somewhat as follows: (Fig. 3).

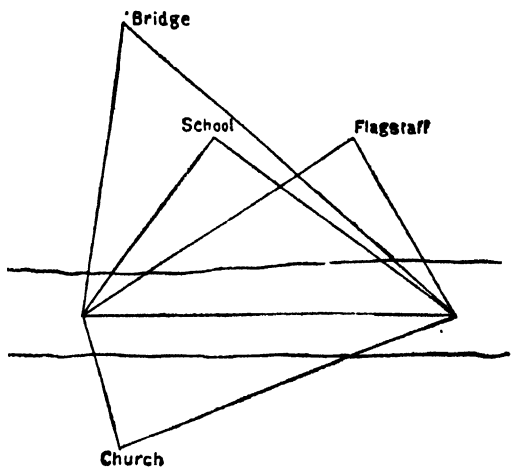


FIG. 3

From this exercise you may go on to more elaborate work, involving the use of the Plane Table or the Theodolite.

It is an easy matter by means of the Plane Table or the Theodolite or the simpler form of instrument called the Anglemeter to find the

breadth of a river. The diagram shows clearly the method (Fig. 4).

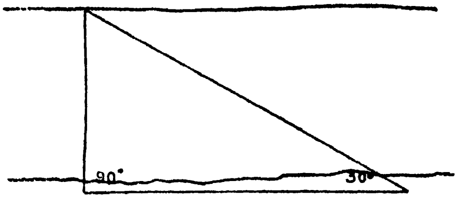


Fig. 4.

To Find Latitude and Longitude.—All these results must be checked by comparison with the map. If you look at the map you will find that the latitude and longitude are given. It is possible without any elaborate apparatus to find these with approximate accuracy. It is easiest to find the latitude from the Pole Star. The theory will be plain from the figure (Fig. 5).

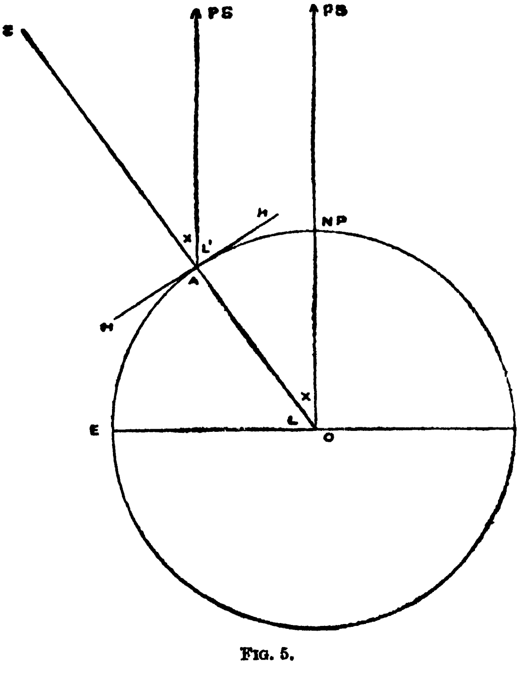


Fig. 5.

If the observer is at A, the centre of the earth is straight below him—*i.e.* along AO; if he looks straight overhead, his line will be AZ to the zenith; his horizon will be along the line HH. The latitude is the angle EOA, marked L in the figure. The Pole Star is straight above the Pole. (This is accurate enough for our purpose.) The distance of the Pole Star is so great that the lines from A to PS and from NP to PS are parallel. Therefore the angles marked X are equal. Now the two angles L and L^1 which are their complements are also equal. The problem, then, is to measure either angle L^1 or angle X.

Now take a piece of cardboard with one straight edge, as long a piece as you can get (Fig. 6). Rule a line parallel to the top edge. At each end of the line glue a rectangular piece of

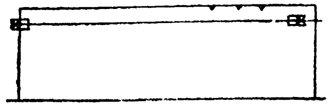


Fig. 6.

cardboard prepared thus. Cut them the same size, and cut them half through the centre, so that they may be folded up at right angles. Make an eye hole in the one, and cut a V-shaped notch in the other. In the upper edge of the cardboard cut three notches. Hang a loop of thread over the cardboard, and fasten a weight at the end, so that it may hang from one of the notches. Then point the cardboard at the Pole Star, looking through the eye hole and getting the star in the centre of the V. Grasp the thread as it hangs down, and mark its position. Repeat this for each of the three notches. The position when pointing to the star is as in diagram (Fig. 7). As the thread hangs downwards the dotted line points to the zenith, and the angle marked X is the angle X of Fig. 1. This angle can be measured with a protractor, taking the average of the three results. Subtracting from 90° gives L^1 or L. Compare your result with the latitude as given in your map.

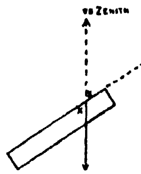


Fig. 7.

With a sextant of course the altitude of the Pole Star can be found without any trouble.

The finding of your longitude is a question simply of finding the local noon. As the sun appears to travel round the heavens in twenty-four hours, it describes 360° per day—*i.e.* 15° per hour, or 4 minutes for every degree of longitude. If, then, you find the time when the sun is exactly due south you have found local noon. A correction must be made according as the sun is before or after the clock; this can be found from *Whitaker's Almanack.* If, then, your local noon is, say, four minutes past twelve, that means that it is four minutes since the sun was due south at Greenwich, and therefore the earth has rotated one degree. Your longitude is accordingly 1° west of Greenwich. This will give you the principle on which the finding of longitude is based.

Weather.—A good deal can be done locally in the study of weather. It is generally possible to discover the monthly rainfall as given by some local rain-gauge. This can be represented on a diagram, the rainfall for the different

months being represented by columns of corresponding height. Compare this, if you can, with the rainfall in other parts of your own county. If there are any marked differences, there is a reason which ought to be sought out. Compare also with the rainfall of other parts of the country. Certain winds are more likely to be rain-bearing than others. Which are they?

It is important to know the direction of the prevailing winds; this can only be done by keeping note of them over some considerable time or making use of the labours of others in that direction. Do these winds reach you after passing over some considerable stretch of country, or do they come straight from the sea? And in your district are they blowing over rising ground or not? This is an important factor.

A knowledge of the temperature is also important. You ought to be able to tell whether the seasonal range is great or the reverse, and similarly with the daily range. It is a useful exercise to keep a record of the daily maximum and minimum temperatures and the mean of these. The mean may be recorded as a graph on squared paper, and on the same paper may be put the mean temperature of some other place. Many daily papers give a list of such places. If you are inland, choose for comparison a place at the seaside, and vice versa. Even in the course of a month or two you may get instructive results, but such a comparison to be of real value ought to be carried on over at least a year. Otherwise you must take for granted the statements of other people; but the practical exercise is of great value, and the more of such exercises you can do for yourself the better a geographer you will be. For one of the aims of geography is disciplinary, and results in a certain habit or attitude of mind, which such exercises foster.

These details have an obvious connection with the occupations of the people on the land, and this connection should be worked out as far as possible.

County Topography.—The county area has already been brought in to some extent, and some study of this can be made. You have already found its area. Now examine its boundaries. See if the area includes a river-basin (or more than one). This is a common type of county, and such a unit is one of the most natural divisions of the country. For within the basin there are, as a rule, no great difficulties of communication, and the river itself plays many useful functions. You will probably find that the boundary of your county is along the water-parting. If it diverges from it, there will be some historical or geographical reason for this. A few counties have a river as their boundary; for this there is a historical explanation.

Look at the site of the county town. How did it come to be there? Is it still the largest town in the county? Is it increasing in population? In answer to these questions there are definite reasons to be given, which you will probably discover quite readily when once you begin to formulate them.

Compare the density of population with that of other counties. If there is a fishing population, where are the fishing grounds, and why are they there? If there are any manufacturers in your county, state as definitely as you can the reasons for their being where they are. The general reasons are the existence of a coal-field, the presence of iron, convenience of situation for the introduction of raw material and for the disposal of the manufactured articles. There will be other occupations in the county; name as many as you can. Tell what goods are exported from the county and imported into it, and give as far as you can the sources of the imports and the destinations of the exports.

With these facts in your mind consider the means of transport. If your county is on the coast, then sea-borne commerce may be of the greatest importance, and the distribution of the towns may bear a definite relation to the coast.

River and canal traffic may account for a good deal of the commerce of the county. In many cases industries flourish in proportion as there are canals as cheap means of bringing raw material to the neighbourhood.

Then there are railways and roads. Notice whether these follow certain lines. See if communication is equally good in every direction from your neighbourhood. If there is a trend in one direction, notice whether there are geographical obstacles in other directions. Possibly important towns have to be connected by road or rail when there are no natural lines of communication between them. In that case observe how the difficulties have been overcome.

Where do people go usually for their holidays? Are there any health resorts which have grown up to meet the needs of the industrial population? If so, what considerations have determined the growth of the resort in the place where it is?

Sites of Towns.—You will find that many, indeed most of the towns or villages in the county are situated in places which have numerous advantages of situation; many roads may radiate from a town, a canal may run through it, the railway passes through it, minerals may be at its doors, it may be a natural centre for the collection and distribution of local products. But often the site is not now the most convenient. In that case there must have been some historical grounds for its present position, reasons for its place which have been gradually losing their weight. Still the town may prosper. For once anything is established, there is a tendency for it to perpetuate its existence. Vested interests are established,

which, once established, are difficult to dislodge. Capital has been sunk, trades grow up in the locality, costly arrangements are made for food supply being brought. These things cannot be overturned without great sacrifice, and the result often is that plans are made to overcome the disadvantages which have arisen with altered conditions. This is what is known as geographical momentum or inertia. You may be able to give some examples from your county. It is often easy to find examples on a small scale. The local post-office may now be in a side street which was once the main thoroughfare till other roads were widened or other quarters became more fashionable. There may be a railway junction near which might with more advantage have been situated elsewhere had not some original difficulty about acquiring land prevented the ideal site being chosen. Though that difficulty may disappear, the junction may not have been changed. The search for samples of such inertia is a very instructive one.

The above sketch gives in outline the sort of geographical work that may be done locally; and without a foundation of this kind geography loses a large part of its value. But geography does not end at home, and it is now necessary to take a wider view.

The Earth.—The hypotheses dealing with the *origin* of the earth lie beyond the scope of geography. The *shape* has been the subject of investigation along many lines. The doctrine that the earth is flat gave way long ago. That it bulges at the Equator and is flattened at the Poles was first suggested by Newton, who reasoned from the rotation of the earth. This does not exhaust the question. The southern hemisphere differs from the northern, and probably the Equator is not a true circle. As has been said, "The earth is earth-shaped."

The most striking fact to be noticed on looking at the globe is the great preponderance of water. Within recent years a theory of the form of the earth known as the "tetrahedral theory" has become prominent. It has been widely accepted by geographers and geologists, though the argument has been attacked by several physicists and mathematicians. The theory, however, seems to meet all the essential facts.

The points for which explanation are sought are these:

1. The distribution of land and water is such that there is a land hemisphere and a water hemisphere, as shown by most atlases, but better seen on the globe itself.

2. Most lands taper to a point in a southerly direction.

3. The continents are roughly triangular in shape, and so are the oceans. If one may be permitted a homely illustration (Fig. 8): a melon is often cut in two by a series of zigzag lines round the middle, as in sketch. If now the upward-pointing teeth are regarded as oceans, and the downward-pointing ones as continents, you have the interlocking arrangement of the land and water of the globe; only there will be but three teeth for the seas and three for the land.

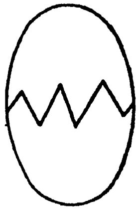


FIG. 8.

4. With one exception, every large land mass has opposite it on the globe a large water mass.

5. The land is arranged as a great ring round a north polar ocean, whereas in the southern hemisphere the water is arranged in a ring round a south polar continent.

Theories as to Shape of the Earth.—In explaining these facts the tetrahedral theory starts from the sure ground of the original spherical or spheroidal shape of the earth. This gives the smallest possible surface for a given volume. But the crust of the earth has become rigid with the lapse of ages, while the interior has remained fluid in the sense that it flows like a fluid under pressure. Now the earth is a contracting body, and the surface has to collapse to accommodate itself to the lessening volume. But the surface or crust is now more or less fixed in area, and the earth therefore tends to assume the shape which will give the largest possible surface for a given volume. This shape is the tetrahedron. To follow the argument, a model tetrahedron may be made from cardboard or stout paper by cutting along the outside lines of the figure and folding along the inside lines. You then have a four-sided figure bounded by the four faces *a, b, c, d,* (Figs. 9 and 10.) The figure may be cut out of soap or modelled from clay. If you hold the figure point downwards you have the shape that the earth tends to assume. It has collapsed along the four faces and ridged itself up along the four edges. The water has collected

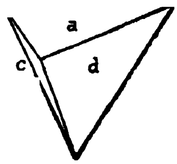


FIG. 9.

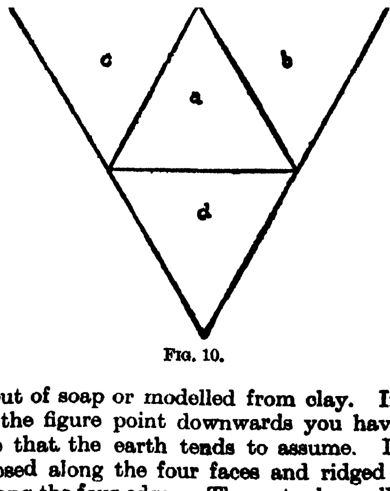


FIG. 10.

at the lowest points; that is, the parts nearest the centre—*i.e.* in the faces. Each apex has a sea opposite it; the continents arrange themselves round the North Pole, and extend in three lines towards the South Pole; the South Pole itself is a land area. The three land lines are represented by America, Europe and Africa, and Asia continued by peninsula and island to Australia. The ring of land round the North Pole is broken in one place, where the Atlantic stretches into the Arctic, but geological history tells us that there used to be a great land area there, and even now the depression below the surface of the ocean is insignificant. Naturally the relative resisting powers of the rocks composing the crust have produced departures from true tetrahedral symmetry.

It is along the lines where the crust of the earth has been ridged up, and which thus form lines of weakness, that there occurs the greatest development of volcanic activity and that the great earthquake regions of the world are found.

Further investigation of the theory would be out of place here, but so far as the facts of the earth's form are concerned, they are as stated, whatever theory may be adduced in explanation of them.

Distribution of Mountains.—Of the land forms of the earth the greatest mountain mass occurs in Asia, structurally continuous with the Caucasus, the Alps, the Sierra Nevada, and the Atlas Mountains in North Africa. They are young mountains ridged up by pressure against the older land blocks which survive in worn-down plateaux. The effect of the great land mass of Asia on climatic conditions will be discussed later.

North and South America present similar features—a high mountain system along the west coast, a central plain, and another system of mountains in the east. The eastern mountains were probably built up of material derived from land stretching into the Atlantic, and in each case the central plain was once under the sea. To some extent the structure of Australia corresponds to that of America, but with the arrangement reversed. The mountains are to the west, and the east possesses the lower ancient plateau. There is a great central plain, but it was never entirely covered by the sea; and the eastern mountains are geologically different in history from the Andes.

Africa, excluding the Atlas Mountains, consists essentially of an elevated plain, descending in terraces to the sea. This has meant great difficulty in commerce, for though the rivers are navigable for long distances once you get inland, they enter the sea by great series of rapids which are not navigable; and railways have great engineering difficulties to overcome before they surmount the terraces and reach the undulating plain above.

Elevation above the sea is one important factor in the climate and habitability of the land. For every 270 feet of elevation there is a fall in temperature of 1° F. Thus high land in temperate regions may become too cold for human occupation, and on the other hand, high land in equatorial regions may become cool enough to be habitable even by white races. To take one example, Quito, in South America, is just on the Equator, but it is at an elevation of nearly two miles above the sea and its temperature month by month remains practically at 55° F.

Coastal Types.—The meeting-place of land and sea gives rise to various types of sea coast. A distinction of the utmost importance is that between "Atlantic" and "Pacific" types. The Pacific type is the more simple. Here the mountain chains lie parallel to the coast, and if there has been any submergence of the land, the submerged area shows as long lines of islands arranged in festoons.

With the Atlantic type the trend of the mountains bears no relation to the direction of the coast, and the coast becomes more varied and advantageous to man. This division of types extends to all the continents. In Australia the eastern coast is Pacific in type, the others are Atlantic.

Some coastal indentations are great wide sweeps inland, like the Great Australian Bight. These seem to owe their origin to the subsidence of land that once stretched across them. Long narrow inlets called rias are due to the submergence of old land valleys. They are often known by other names; the terminology, indeed, is not in a satisfactory state. Bantry Bay and the others on the south-west coast of Ireland are rias. A fiord is a long narrow opening with many branches, which is shallower at the mouth than farther inland, such as the fiords of Norway and many of the west Scottish lochs. The explanation of these is by no means agreed upon as yet. They occur in tablelands that have been much fractured and then partly submerged, and they show evidence of having suffered glacial action.

The submergence of the land may go so far as to produce very complex coasts, with many peninsulas, bays, gulfs, and islands. The Clyde firth is an example of this, and would produce a still more complex coast were the land to sink farther.

There is a distinct prolongation of the continents below the level of the sea. This prolongation is known as the continental shelf. It varies in size in different parts of the globe. This shelf is extremely narrow round Africa; it is broader on the east than on the west of America, and includes all Hudson Bay. In the north-west of Europe it includes the North Sea and extends far beyond Britain. Islands rising from the continental shelf are continental

islands. It is a most instructive exercise to draw a section across the North Sea and Britain out to the deep water of the Atlantic. An orographical map of Europe will give you sufficient detail for the purpose. If you draw the section on stiff paper or cardboard and cut it out and stand it up you will have an excellent impression of the difference between the continental area and the oceanic. The shallowness of the North Sea is remarkable, and not easy to realise. Only the deep Norwegian gulf is more than 600 feet deep. Either your local railway station or someone near has a platform more than 200 yards long. Then that platform, if stuck on end anywhere in the North Sea, would be seen above the water.

Atmospheric Circulation.—In a study of geography one of the prime essentials is a knowledge of the fundamental circulation of the atmosphere due to the fact that the earth is a planet rotating on its own axis and at the same time revolving round the sun. From this we have what are known as Planetary Winds. An understanding of these and an acquaintance with the configuration of the main land masses will go a long way to making clear a large amount of geographical material, from questions of climate through those of flora and fauna even up to those of the development of civilisation in the races of mankind.

Consider the state of affairs on one particular day, the Vernal Equinox. The sun is directly over the Equator, with the result that the equatorial belt of the atmosphere gets very much heated up: it expands, becomes lighter, and consequently there is a flow of heavier air displacing it from the north and south. This heavier air in its turn becomes heated and rises. In this way a constant flow of air is kept up, blowing towards the Equator. Owing to the rotation of the earth this flow does not produce due north and south winds; the air that comes from northern and southern latitudes is rotating more slowly than the Equator, towards which it is moving, and this produces the impression to an observer that the wind is coming from the north-east and the south-east.

These winds, coming as they do from a colder to a warmer part of the earth's surface, are growing warmer as they move, and therefore capable of holding more moisture. They are thus, except for some special reason, drying winds. They blow with great regularity, and are known as the "Trade Winds."

Meantime the air at the Equator has been rising, and expanding with the diminished pressure. This produces cooling and inability to hold as much moisture as formerly. There is thus a state of heavy rainfall in the region of the Equator, known as the equatorial rain-belt.

This rising air flows out from the Equator in the upper regions of the atmosphere, and about latitude 28° north and south the additional atmospheric pressure produced by this upper layer has the effect of checking the flow of air towards the Equator, and inducing instead a flow polewards from the region of high pressure.

These winds would be due south winds in the northern hemisphere and due north winds in the southern, but for the fact that they are moving from a quickly rotating part of the earth to one moving less quickly. They therefore have their motion deflected so as to become south-west and north-west winds respectively. The latter are often known as the "Brave West Winds," and the latitudes in which they blow are known as the "Roaring Forties."

They are not so regular as the trade winds, and are the very reverse of drying winds. Coming from a warmer to a colder part of the globe they become cooler, less able to retain moisture, and therefore they are, as a rule, rainy winds. A common name for them is the "Anti-trades."

Thus at the Vernal Equinox the globe may be divided into the following regions. First, a belt of calms along the Equator, in a region of low pressure, and therefore very rainy; second, two trade-wind regions, with steady drying winds; third, beyond the trade winds two areas of high pressure, calm, free from rains; fourth, regions where the prevailing winds are westerly, irregular in the north, more regular in the southern hemisphere, and rainy. Beyond these regions are other belts of calm, and, lastly, the polar winds.

This is the state of affairs at that one time. On that day an observer standing on the Equator would have the sun directly overhead at noon; but on the following noon he would not find the sun directly overhead, unless he were to move some twenty miles north before noon. And the same holds good every day until midsummer day. To have the sun directly overhead at noon, he must keep moving steadily northwards.

Seasonal Movement of Circulation.—But as the whole atmospheric circulation that has been described depends entirely on the heating effect of the sun, it follows that the whole scheme of circulation—rain-belt, trade winds, and all the rest—move steadily northwards until midsummer day. It then begins to retreat until on midwinter day it has taken up its most southerly position. It ought to be mentioned that the movement lags somewhat behind the sun, and that therefore the Equator itself is never outside the area of the rain-belt.

This seasonal movement is of the greatest consequence. The Equator is in a region of perpetual rain, beyond it to the north is a region where there are heavy rains in summer because it is in the equatorial rain-belt for a season, but where the drying trade winds blow in the winter;

then you come to a region that is never out of the trade-wind region, and next to that a region just at the edge of the trade-wind belt, so near the edge that in winter the seasonal movement of the air system brings the wet westerly winds down to it, giving it a summer that is dry and warm, and a winter that is wet but mild. Then comes a region that is permanently under the influence of the anti-trades.

One other fact of the first order of magnitude has to be stated in connection with the atmospheric circulation, though in doing so we are departing from the planetary winds to winds which owe their importance to the configuration of land and water on the globe. The great central land mass of Asia, when the sun is in the region of the Tropic of Cancer, gets very hot, the air rises as it does all along the equatorial rain-belt, and colder winds blow in. This is just as in the case of the trade winds, but this time the place of diminished air-pressure is farther to the north, and the trade winds of the Indian Ocean cross the Equator, change their direction for the same reason that makes the trade winds south-east and not south, or rather that makes the Brave West Winds north-west and not north. and blow over India as the south-west monsoon In winter the wind appears as the usual north-east trade, but crossing the Equator and becoming a north-west monsoon. Thus in the Indian Ocean the winds blow in exactly opposite directions from November to April and from May to October.

We must next turn to the influence of mountains on rainfall. It is a common saying that hills draw the rain, but this attraction is not exactly what it is commonly supposed to be. The real fact is this, that when wind in its passage across the earth's surface encounters mountains, it must ascend in order to cross the barrier. But this ascent means expansion, and expansion means cooling, and cooling means inability to hold as much moisture as formerly. Clouds are formed, and rain falls. This is the reason of the greater rainfall in mountainous districts.

Regions of Great Rainfall, etc.—Now that we have discussed the planetary circulation of the atmosphere and found also the relation between mountains and rainfall, open a map of the world and see how much information you have gained.

1. You may at once mark out all the regions of excessive rainfall. These are along the Equator in South America, in Africa, in the islands to the north of Australia. There is also a great rainfall where the south-west monsoon, laden with moisture from the Indian Ocean, strikes the highlands to the north of India.

This equatorial region of great rain and high temperature is naturally the great region of vegetation. The dense tropical forests produce many plants useful to man. Since vegetation is at its maximum here, it is not at all adapted to being a home of man; indeed the forests are practically impenetrable except along the rivers, and it is here that animals that live in trees have their habitation.

2. You will find great desert areas in the trade-wind belts, unless the winds happen to strike high land in their course. Thus are explained the Sahara and the Kalahari Desert in Africa, the Desert of Atacama in South America, and the desert of Australia. The term trade wind is generally confined to the winds that blow over the ocean; the presence of land introduces an element of uncertainty and of complexity. But this desert area is characteristic of the trade-wind regions. In Australia the wind is deprived of its moisture in its passage over the western mountains, and the whole interior is rainless. In South America the trade winds blow across the continent, parting with some moisture on their way, but bringing the greatest rainfall to the eastern slopes of the Andes, leaving the Desert of Atacama between the western slopes and the Pacific.

The Sahara is only part of a great desert area stretching through Arabia, Persia, Afghanistan, and through Central Asia almost to the Pacific. Here the explanation is of the same type. When the sun is farthest south, the wind blows towards the Equator, as in the trade-wind areas—though it passes south of the Equator and is known as a monsoon. It is then blowing from land to sea and from cold to warm as far as its course over Asia is concerned; that is, it is a drying wind. When the sun is farthest north, the rain-bearing monsoon blows, but it has lost all its moisture on the highlands to the south before it reaches Central Asia.

3. The next area both north and south of the trade winds is an area that has winter rains and summer drought. These areas, from the best known and most developed, are known as Mediterranean lands; the climate is called the Mediterranean climate. The lands are near enough the Tropics to be warm in winter and hot in summer.

Climate and Productivity.—The influence on the productions is bound to be very great, and certain trees are typically Mediterranean in their character, such as the olive, peach, orange and lemon, the vine, the sweet chestnut, the mulberry. These all have some characteristic which enables them to resist the drought of summer. They may have deep roots which penetrate beyond the usual parched ground, their leaves are dun-coloured to exclude the actinic rays of the sun, they may present their edges to the sun, they are glossy and gummy to allow the minimum of evaporation. Wheat sown in autumn ripens with the beginning of the drought; alfa (esparto) grass is grown, and in sheltered, well-irrigated valleys rice of excellent quality can be produced.

Mediterranean climate is found not only along the Mediterranean coasts, but in all other

regions north and south of the Equator that have winter rains. Typical regions of this kind are: California, Chile, South Africa, the South-West and South-East of Australia.

4. Farther on, towards both Poles, there next come the Temperate Zones, with their westerly winds, producing a great quantity of vegetation, with deciduous trees shading off into the conifers of colder latitudes, immense forests which have had to be cleared by the agency of man, and with climate adapted in varying degrees to the cultivation of the cereals which are a great mainstay of his life. As the land of the globe lies mostly in the northern hemisphere, it is in that hemisphere that the greatest development of the temperate region occurs.

Beyond the conifers come the barren Tundras of the extreme limits of the continents, great desert areas, not from want of water but from want of warmth.

The Oceans.—Land forms have now been discussed, and the relation between atmospheric circulation and climate. There remains the ocean.

With one exception, the oceans and seas, &c., forming the hydrosphere are continuous; *i.e.* it is possible to go from one point on the ocean to another without crossing land. The one exception is the Caspian, and evidence shows that its separation is comparatively recent. Its recent junction with the rest of the ocean was not with the Black Sea, as might naturally be thought, but with the Arctic across the Russian plain.

The division of the water into oceans is convenient. The Southern Ocean extends round the world, and its waters wash the Antarctic land. The Pacific is by far the largest, containing an area as large as all the land of the globe. The Atlantic is the ocean towards which most of the land of the globe leans; North and South America, for example, turn their back on the Pacific. The result is that an enormous amount of river drainage takes place into the Atlantic and its connected seas; it is into the Atlantic that the rivers lead men, and from the Atlantic men are led up the rivers into the heart of the land. The Indian Ocean and the Arctic complete the list of oceans.

As a means of communication and as a source of food supply the hydrosphere has had a profound influence on the development of civilisation. At present, however, we shall consider the relation between the ocean, winds, and climate.

The fact that water has a high specific heat means a great deal to mankind. An amount of heat that would make the earth's surface excessively hot will only slightly warm the ocean. On the other hand, when the supply of heat is withdrawn, the earth's surface readily parts with the heat it has so easily acquired, while the water is very slow in parting with the heat it has taken in. The differential heating, and cooling, of land and sea surfaces gives rise to the phenomena of land and sea breezes. In the daytime the land is much hotter than the sea, the air above the land gets heated and expands and grows lighter; the colder air over the sea flows in to the land, and the warm air rises, thus producing a sea breeze which greatly tempers the heat. In the night the land parts with its heat rapidly, and is soon colder than the sea. The air over the sea is now warmer than that over the land, and there is a flow of air from land to sea. In the early days of civilisation this off-shore wind during the night made navigation less dangerous and encouraged the primitive voyagers of the Mediterranean to undertake exploits that otherwise they would never have dared.

There is also a seasonal effect of the same nature, so that in summer lands near the sea have a cool ocean in their neighbourhood, whereas in winter they are in proximity to an ocean warmer than the land. The ocean's slow seasonal change of temperature means that lands that come under its influence have a climate whose changes of temperature are less extreme than farther inland. This is the great difference between continental and insular climates. The mean temperature of Limerick in January is about 41°, in July it is about 60°. The mean temperature of Moscow ranges from about 14° to about 72°. And the contrast between the actual maxima and minima is much greater.

Naturally, too, the rainfall of lands near the ocean is in general much greater than that of continental lands in this sense of the word.

Ocean Currents.—But there is more than this to be said. If you compare the climate of Britain with that of Labrador within the same degrees of latitude you will find that whereas the west coast of Britain has a winter temperature of somewhere in the neighbourhood of 40°, that of Labrador is somewhere in the neighbourhood of 0° F. This leads us to the question of the ocean currents.

These currents follow generally the same direction as the prevailing currents of the atmosphere. Other causes contribute to the ocean's motion, but the chief cause is the steady blowing of the winds over its surface. Their actual course is sufficient to show this.

The currents of the Atlantic have been the most studied, and may be taken as largely typical. The trade winds north and south of the Equator blow the waters of the Atlantic in a relatively rapid current in the same direction. They therefore converge on the West Indies between North and South America and become heaped up there. They have to escape in some direction, and some of the piled-up waters find a way out along the belt of calms at the Equator.

This is known as the Counter Equatorial Current, which off the coast of Africa becomes known as the Guinea Current. Some of the water enters the Gulf of Mexico, becomes enormously heated there, and passes out round the peninsula of Florida as the Gulf Stream. This stream comes under the influence of the anti-trades and makes its way across the Atlantic, but by the time it leaves the coast of North America it has ceased to be distinguishable from the general drift of the waters of the Atlantic. Still more of the water passes round the outside of Florida and is driven by the anti-trades across the Atlantic, the waters of the Gulf Stream mingling with it. It is a warm current and supplies the wind with a great amount of moisture. As it nears the shores of the Atlantic it divides into three. Off the coast of Portugal part of it is deflected and goes again southward and once more is caught by the trade winds. Another part goes past Britain, makes its way along Scandinavia, and enters the Arctic Ocean. Though warm, it is very salt, and is heavy enough to sink below the cold water there. The third branch is deflected by the island of Iceland, and skirts the southern point of Greenland. Meantime the cold water of the Arctic escapes past Spitzbergen and travels round Greenland. From the west of Greenland a cold current is blown by the prevailing wind down the coast of Labrador, bringing icebergs with it. Off Newfoundland it meets the Gulf Stream, and the mingling of cold and warm water causes the well-known fogs off the Banks of Newfoundland.

The South Equatorial Current, flowing under the impulse of the trade wind towards America, does not all accumulate in the Caribbean Sea and its neighbourhood; part of it is turned southwards by the wedge-shaped eastern coast of South America, and flows along the coast of Brazil as the warm Brazilian Current.

These currents blown across the Atlantic by the trade winds receive a large part of their water from the welling-up of the cold water from the deeps of the ocean; therefore they begin their course as cold currents, warming up as they flow, and except where that part of the Counter Equatorial Current known as the Guinea Current flows along the African coast the waters along the west of Africa are cold. This cold water on the west of Africa and similarly on the west of the other continents explains the absence of coral reefs on these coasts. Contrast, for instance, the Great Barrier Reef of the eastern coast of Australia with the absence of coral on the west.

The currents of the Pacific follow on the whole a circulation similar to that of the Atlantic.

In the region of the Brave West Winds there is a current flowing with practically uninterrupted course round the world.

In the northern hemisphere it is evident that with prevailing south-west winds and prevailing warm currents in the same direction there must be a great contrast between the east and west shores of the oceans. Thus Britain and Vancouver, say, are washed by a warm ocean and are blown over by warm, rain-bearing winds; their climate is moist and equable; the corresponding coast of the east of North America faces a cold ocean, and therefore the climate is rigorous. Even farther south beyond the limit of the cold Labrador Current the prevailing winds, being westerly and south-westerly, are off-shore winds, and the land does not reap the benefit of the warm ocean. It is indeed an example of a "continental" climate close to the sea.

The Ice Age and Its Effects.—So far, in the discussion of winds, currents, and climate, we have been considering the condition of affairs at the present time. But this is not a static condition, and one profoundly different state must be touched on; that is, the time of the Great Ice Age. Geologists tell us that there has been more than one such age, but this is apart from our present purpose. For some cause that need not be entered on here, there has been, in a time comparatively recent from a geological point of view, a period when a vast area of the northern hemisphere was drowned in ice. The time is so recent that the effects have not yet worn away, indeed are not yet more than slightly modified. And these effects are, some of them, of great interest to the geographer.

At the time of its greatest extent in Europe the ice covered the whole of the North Sea, the whole of the British Isles except the extreme south of England, all Scandinavia and the Baltic, and Europe generally almost down to the 50th parallel—*i.e.* all the European plain. At the same time the glaciers of the Alps and the Pyrenees were of great extent.

In North America the glaciation was at least as extreme.

A few of the effects may be mentioned.

In valleys worn out only by running water the course of the river and its tributaries is more or less continuous, and the shape of the valley tends to be V-shaped. In glaciated valleys there is a discontinuity between the river and its tributaries, the tributaries joining the main stream in a series of cascades; and there is an equal want of continuity in the main stream itself. The valleys are U-shaped, and at the top of the U is a level stretch covered with glacial debris of great fertility.

Sometimes the ice has worn passes in the hills that separate two river systems, affording valuable means of communication from one valley or plain to another.

Many lakes, too, owe their existence to the action of the ice either in hollowing out the floor of the lake or in blocking up the natural exit of the water by morainic deposits or both. The

great lake system of North America, for instance, is a legacy from the Ice Age.

Influence on Flora and Fauna.—But perhaps the most important effect of the Ice Age has been its influence on flora and fauna, in Europe especially. In North America the flora and fauna were pushed southward by the advancing ice, but as the ice retreated the flora and fauna crept up again. But the case was different with Europe. There flora and fauna were practically pushed into the Mediterranean. This accounts for the relative paucity of these in Europe compared with America or Asia. And it has made it easier for man to gain and keep a footing in Europe. He would have none of the struggle for existence with the larger and more voracious mammals that would otherwise have been his lot.

It is to be noted too that when man introduced the flora of Asia and America into Europe, it adapted itself naturally to its new environment. This confirms the evidence that the Ice Age killed it out in Europe; there seems to be no present climatic obstacle to its existence.

Distribution of Population.—Preceding sections are of fundamental importance in the development of mankind and in the distribution of population. We need not enter here into the question of the original home of mankind, or trace his evolution through the different stages up to and through the Stone Ages to the introduction of the use of metal and the succeeding steps in civilisation. Man began as a hunter and fisher, and came later to the pastoral and agricultural stage. During the hunting stage the land must have been thinly populated; agriculture indicates a much greater density of population. But these points are obviously connected with fertility of soil and the character of the flora and fauna, to which again the climate is intimately related.

If the primitive home of mankind was, as is commonly held, a Gondwanaland extending over the site of the present Indian Ocean, then in the dispersal of mankind migrating peoples would find a suitable home in the Mediterranean lands. The climate was congenial there, partly due to the protecting barrier of the Alps which shut off the cold winds from the north. In the course of time as agriculture developed (and if, as is probably the case, the climate became drier) the Mediterranean race would find out the advantage of irrigation, and this implies a life as a community where mutual assistance can be given. Incidentally it may have weakened the acceptance of the family as the natural unit and also laid more stress on the life of the community than on the individual life.

When man made his way into temperate Europe, he found that the struggle with nature was harder and made a greater strain on his powers. This all made for progress; for his powers were developed in proportion to the demand made on them. This Nordic race has evolved a distinctive civilisation of its own. In it we find that the family has a higher place as a unit than in the Mediterranean lands, for in this case the contest with the forest or with the sea demands a family rather than a communal life.

Influence of Mineral Wealth.—But if we look at a map showing the density of population in Europe we should find at once that the distribution of population is not in full accord with what we might expect if our knowledge went no further than climate and soil. Places relatively infertile and apparently less suitable as a home for man have a very dense population. The explanation is that still another factor has to be considered; that is, the presence of mineral wealth. Where coal is, there a great population will spring up. The Industrial Revolution in which Britain led the way, and which gave to the world the steam engine and the use of new inventions in machinery and brought the coal and iron fields into greater prominence, meant a geographical revolution as well. It shifted the centre of power from the agricultural districts to the manufacturing, and brought about an enormous increase in and redistribution of population. That these advantages lay with the Nordic races in Europe, rather than with the Mediterranean, has given the former an enormous "pull"; whether they will keep it as other means of power are developed or discovered is a matter that lies with the future.

Not only has the population been redistributed; it has meant the localisation of industry in large towns, which have grown at the expense of the rural districts. This essential concentration of man in large towns is a comparatively recent feature in history, and it may be only a transient one.

The next important mineral to coal and iron in the development of Europe is probably salt, but other metals and minerals also play their part. The absence of great gold-fields has meant the absence of those mushroom cities which have sprung up in other parts of the world.

To sum up, a knowledge of the climate, of the character of the land—its fertility, accessibility, and the rest—and of the mineral wealth, supplies the key to the present distribution of mankind over the globe. With these facts in view a rapid survey of different regions of the world must now be taken. We shall start with the home land, though other methods of attack have also much to recommend them. It is to be noted that in all that follows, as indeed in most of what has gone before, a constant use of the map is assumed. A mere reading of the text is practically valueless.

THE BRITISH ISLES

With a piece of squared tracing paper you can easily calculate from a map the area of the British Isles. You will have a little calculation to do to find what area each square of your tracing paper represents; the scale given on your map enables you to do this. You will find that the area of the United Kingdom is about 121,000 square miles. This in itself has very little meaning to the ordinary mind, but comparison with other areas will be a help. You may find out, for example, how many times it is bigger than your county. Or you may find out the areas of other European countries and compare these with the area of our own. They can be represented in diagrammatic form. France and Britain are represented below (Fig. 11).

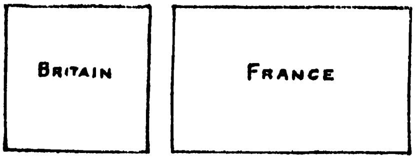


FIG. 11.

Britain comes eighth amongst the countries of Europe in order of size. Australia is about twenty-five times as large.

It lies almost entirely within the lines of 50° and 60° N. long. and the lines of 0° and 10° W. lat. If you take a globe and roll it over the table till you have the land hemisphere uppermost you will find that London lies at the centre. This has been of great importance in the prosperity of the country. With the discovery of America Britain came to occupy the central position in the world instead of lying on the outskirts of civilisation.

It stands on the continental shelf of Europe, and this has had something to do with its prosperity. For the sea bed has been sheltered from the cold waters of the bottom of the Atlantic and Arctic oceans; this has meant a great deal to the fishing industries, and has meant the rearing of a fishing community which forms the basis of our sea power. It is the continental shelf, moreover, that increases the range of the tides with great advantage to our ports.

If you have drawn a section across the continental shelf you will have no difficulty in realising that the North Sea may once have been dry land, as indeed it was, for a period that is short only in a geological sense, and its submergence must have taken place within a comparatively recent time, judging from the bones of animals, such as the elk and the bear, that have been dredged up from the Dogger Bank in the centre of the sea.

Origin of the British Isles.—The history of the changes the land has undergone belongs to the domain of geology rather than that of geography, but a good many geographical facts find their explanation in the previous history of the land. Here it will suffice to say that the present British Isles are derived ultimately from a vanished continent lying to the north-west. The edge of the Scottish Highlands and of the Hebrides formed part of a great land stretching from Scandinavia to Greenland, variously called Arctis or Atlantis by geologists. Along the continental edge great changes took place, and after many vicissitudes, the last of which has been the formation of the Straits of Dover and the separation of Britain from Europe, the islands as we know them finally appeared. Some of these vicissitudes will be referred to later, but it is sufficient to note here the structure which has resulted.

Ireland has been compared to a tea-tray, with a rim of mountains enclosing a great plain of poor economic resources. Scotland is divided into three great divisions: to the north and north-west are the Highlands; then comes the midland rift valley, separated from the Highlands by a sharp line extending from Stonehaven on the east coast to Helensburgh on the Clyde; next, separated from the Midland Valley by a less well-defined line stretching from Dunbar to Girvan, come the Southern Uplands. In England the mountains lie also to the north and west, the south-east is a plain, and the land lies sloping towards Europe. This has been of great importance in the history of the island.

The mountains are all "mountains of circumdenudation," that is, that whatever their previous history, they have really been elevated plains with a slope in one direction or other, and that those plains, chiefly by the action of running water, have had valleys carved out of them until they appear as a system of hills and valleys. If one at the present time stands on a mountain-top in the Highlands the general appearance of the hills will in itself be almost sufficient evidence that the land was at one time at the level at which one is standing: none of the summits stand out conspicuously above the others, and one could easily imagine a vast rain-cloud just touching all the mountain-tops. Indeed the original mountain structure has been worn down to an almost incredible extent.

Direction of Rivers.—The lie of the land has determined the direction of the rivers, and therefore, as is to be expected, most of the large rivers flow east and south-east. There are exceptions, perhaps the most interesting being the Severn and the Clyde. In the case of the Severn there is evidence to show that the river did not always discharge its water into the Bristol Channel, but formerly continued its way south-east and flowed into what is now the Thames. Then the waters of the Severn were "captured" by a stream which gradually worked its way back

from the Bristol Channel along the foot of the Cotswolds. This stream is represented by the present Warwick Avon. There are many examples of "capture" of this sort.

In the case of the Clyde the flow of the river is now north-west. If you consult a map you will see at the mouth of the Clyde, in a line with the river itself, the Gare Loch. Follow this up across Loch Long, and you come to Loch Goil. Now there is distinct evidence that before any of these lochs came into existence by the submergence of the land surface the river Clyde actually flowed along the valleys where Loch Goil and the Gare Loch now stand, and then along the valley of the Clyde, but in a direction exactly the reverse of its present one. It may have entered the sea by the Firth of Forth or by the Tweed valley. You will see from the map that the course of the Tweed is in a line with the course of the Clyde. The history of the complete change in direction of the river is a complex one, and a good deal of it depends on conjecture. But there seems no doubt that the river originally conformed to the general trend of the river system, and subsequently changed, to the great advantage of Scotland's prosperity.

Coast-line.—Britain is pre-eminently well supplied in respect of coast-line. A glance at the map will show how much indented the coast is. This brings every part of the island within easy reach of the sea. No part is so much as an hour's journey from the sea for an airman. Therefore every part is climatically under the influence of the ocean. That means an absence of extremes of climate, and gives the maximum possibility of open-air work throughout the year. You will see from the map that the west coast is much more indented than the east. This is due to the structure of the land. In the Highlands of Scotland, for instance, the grain of the land has a north-easterly direction. Mountains and valleys run parallel to this direction. When partial submergence took place the sea flowed up the valleys and gave the west coast its indented appearance.

But in all part of the islands there are plenty of good harbours formed by river mouths, and therefore a goodly choice of situations for ports. From these ports the land is opened up by the rivers into the interior, and this has made export and import easier. North of Glasgow there are no great ports though the inlets are many. This is because there is no hinterland to these harbours, and communication into the interior is a practical impossibility. But Glasgow itself is almost ideally situated as a great port, facing America, and having behind it the richest hinterland in Scotland. You will observe, too, how the ports of the east coast of Britain face the ports of the Continent; river mouth is opposite river mouth. This is no accident, and is based on geological history. While the North Sea was yet land, the Rhine and the Elbe, the Thames and the Yorkshire Ouse, were all tributaries of one great river flowing northward to some mouth beyond the Shetland Islands. Similarly, the Seine and the rivers of the south of England were parts of a river that flowed along the bed of the English Channel to join the sea westward. These facts have greatly facilitated intercourse with the adjoining lands of the Continent.

The climate of Britain, as has been said, is temperate. One would naturally expect that there would be a steady decrease of average temperature from south to north. But this is not at all the actual condition. The influence of the sea and the prevailing winds comes in to modify the expected condition.

Isotherms are lines drawn connecting places where the temperature is the same. Now there is an essential difference between the isotherms of Britain for January and for July. The July isotherms follow more or less the expected course, *i.e.* they run more or less parallel to the lines of latitude (but only more or less). There is a general decrease of temperature from south to north. But in January the lines do not follow this direction at all. They have a direction that is practically north and south. This is accounted for by the influence of the sea and the warm winds that blow from the south-west. Thanks to these influences there is a winter "gulf of warmth" stretching over the Atlantic as far as the west coast of Scandinavia. It may be instructive to compare the temperatures of four typical places, one in the extreme north of Scotland, one in the south of England, one in the west of Ireland, and one in the heart of the country. Selecting (1) Thurso, (2) Isle of Wight, (3) Valentia, (4) Derby, they may be represented thus (Fig. 12):

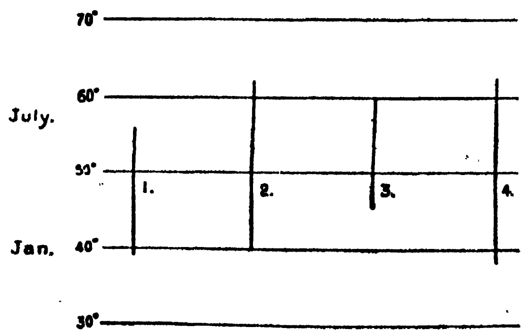


FIG. 12.

You will observe that Thurso, and still more Valentia, have a very high winter temperature considering the latitude. Both have a relatively small annual range of temperature. The highest range is at Derby, which is inland, and

therefore as far as it is possible to be from the equalising influence of the sea.

If you look at a map showing the isotherms for January and July, you will see that the 42° line in winter takes a bend northward over the Irish Sea, owing to the warming influence of the sea in winter, and that the 59° line takes a southward bend in summer owing to the cooling influence of the sea in summer.

There is a very distinct difference between the west and east of the country as regards rainfall. The region of greatest rainfall lies to the west, because of the higher land there. The prevailing winds are westerly, and are laden with moisture when they reach this country. Whenever they strike the high land in the west they are forced to rise and part with their moisture; they therefore continue their course over the country as dry winds. The east of the country is therefore in the rain shadow of the mountains. Those acquainted with the east coast know that with a west wind the weather is likely to be dry, but an east wind is likely to bring rain; on the west coast the very reverse is the case. The part of the country with the greatest range of temperature and the lowest rainfall is in the counties of Norfolk, Suffolk, and Essex. These are therefore the counties that are most suitable for the growing of wheat, and it is there that wheat-growing reaches its greatest development.

Influence of Coal-fields on Distribution of Population.—The Industrial Revolution meant that wherever coal-fields are to be found a great population would settle, for it is easier to bring the raw material of manufacture to the coal-fields than vice versa. There is a tendency nowadays to depart from that, and that tendency may be accentuated as time goes on. But at present, with few exceptions, manufacture is carried on in the coal areas.

Coal is the result of a period in the physical history of Britain very different from the present. With a tropical climate and a swampy soil, vast forests and jungle grew up and became buried in the moist ground or were swept into lakes and seas. It is from this material that our coal is derived. The whole of the land was not under these conditions, but a great amount of coal which was once laid down has been removed from the land through long ages of erosion.

Thus the coal which once covered the whole of the Pennine range has been removed, and only the coal-fields to each side and to the south have been left. In the same way the subsidence of the midland valley of Scotland protected the coal, and is largely responsible for the wealth of Scotland. Unfortunately for Ireland, there was no protection for its coal measures, which once stretched over nearly all the area, and which have been practically all worn away.

Coal is by far the most important mineral of Britain; iron, which comes next, is a long way behind. The diagram shows the value of the coal mined compared with iron (Fig. 13). The

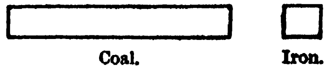


Fig. 13.

other metals of Britain are of so small a relative value that they could hardly be shown on the same scale at all.

England and Wales.—*Physical Features.*—The high lands, as has been said, are to the north and west. The Cheviots form a natural boundary between England and Scotland. From these a long range—the Pennines—extends into Derbyshire. This has confined the land communication with Scotland to the two coast lines, and of these the east route was much the more important in earlier times. The railways into Scotland follow one or other of these routes.

The Pennines are breached in places by the action of rivers, and these gaps are of great importance in affording communication between the industrial centres to the east and west. The more important are the Tyne gap and the Aire gap, both traversed by railways. Farther south the cross railways utilise as much as possible the river valleys, but have to make use of tunnelling to join the valleys on opposite sides of the ridge.

In Cumberland are the Cumbrian Mountains, containing the highest point in England and containing the beautiful Lake District.

The Cambrian Mountains are in Wales. They were the refuge of Celtic tribes who held out against the Norman kings. But their conquest was rendered easier by the fact that so many water-ways penetrate the heart of the mountains.

An important opening, the Midland Gate, gives access to the sea at Chester.

The remaining high land is in Cornwall and Devon, also a shelter from invaders, and still occupied by a people differing in blood from the bulk of the inhabitants of Britain. The china-clay derived from the breaking down of the granite is transported by sea and canal to the Potteries situated on the North Staffordshire coal-field.

The rest of England is essentially plain, but the high land of the North and South Downs has been of importance historically.

Originally the south-eastern part of England was by much the more important, roughly below a line from the Wash to the Bristol Channel. It had easy communication with the Continent and was the more fertile part. It has been called Metropolitan England, because its centre of life is unquestionably the metropolis. Only two towns outside London in the whole

area have a population of 200,000. Many facts show that the whole area looks to London; it is an illustration of this that even from so remote a city as Gloucester trains are run to take the inhabitants to the London theatres!

The people of Metropolitan England are occupied in: (1) agriculture—the richest wheatlands are in East Anglia; (2) providing for the pleasure of London—Brighton has a population of over 100,000; (3) fishing, as at Yarmouth; (4) naval construction and defence, as in Portsmouth, Plymouth and Devonport, and Dover; (5) traffic with the Continent and the rest of the world. Southampton has certain advantages. Thanks to the Isle of Wight it has double tides, one by the Solent and one by Spithead. It also gives the shortest land line to London, and by taking advantage of this the crowded passage through the Straits of Dover may be avoided. Bristol is an important port. It first rose to importance as being a port facing Ireland, and then America; tobacco, cocoa, and West Indian fruits are imported; but Bristol has been placed at a disadvantage by the increase in size of the great liners.

Tin is still mined in Cornwall. It may become one of the greatest centres for the supply of radium.

Cities and Towns.—London has long been the greatest city in Britain. Its importance dates from the time of the Romans. During the Saxon invasions London held out so as to bar the way to the invaders and thus prevent their spreading up the Thames valley. This is the explanation of the fact that the Thames in every part of its course is a boundary between counties; the invaders had to approach the Thames from two opposite sides. London owes its site to London Bridge. Beyond it on both sides were marshes which prevented approach to the river. But from London Bridge roads could radiate in all directions, and the bridge once built implies the stoppage of all navigation which came from the sea. It is still the centre from which roads and railways radiate to all parts of the kingdom. It is the centre of government, of law, of science, of art, and of literature. Though having no distinctive manufacture, it is the largest manufacturing centre in the land; almost one-sixth of all the shipping that enters British ports enters London.

The coal-fields have in little over a century transferred the whole balance of population to the north and north-west of England, with of course the exception of London, whose commanding position nothing seems to threaten.

But Manchester has now become the centre of an enormous population engaged in cotton manufacture. This it owes to the coal and iron, to the great port of Liverpool facing America, which was at first the only source of the raw cotton, and to the damp climate which facilitates the manufacture of the cotton. As a seaport Liverpool ranks next to London; it is the port not merely of the cotton industry but of all the Black Country, and even to some extent of the woollen industry.

The woollen industry is carried on in the West Riding of Yorkshire. Here Flemish weavers settled when driven from their own land, for here they could get wool from the sheep of the Pennines and soft water for washing it, and water-power for their looms. Now the power is obtained from coal, and most of the wool is imported. Leeds is the principal town, but there are many others of great importance.

The chief metal and machinery towns lie in the Black Country. Birmingham, the centre of these industries, does not itself lie on a coal-field; it used to draw its power for the smelting of iron from the charcoal provided by the Forest of Arden. There are numerous important towns on the coal-fields, all engaged in some branch of iron manufacture.

Another great iron town, Barrow, in the Furness district of Lancashire, though having rich iron ores, is not on a coal-field.

Near the Black Country are the Potteries, in the Trent valley, on the North Staffordshire coal-field. The clay for the pottery was originally got locally, but now most of it comes from Cornwall and elsewhere. Of the "five towns" Stoke is the chief.

In Cheshire salt is found. The presence of millstone grit for making grindstones made Sheffield important as a manufacturer of cutlery, though Sheffield plate and other goods are also manufactured.

The Durham coal-field has made the Tyne one of the great shipbuilding centres of the world. Newcastle has grown up at the lowest place where the river could be bridged. It has a great export of coal. Middlesburgh gets its coal from this coal-field and its iron from the Cleveland district hills.

North Wales has a coal-field, but it is of small importance compared with the South Wales field. The latter coal is of special value as steam coal, and a great export trade is done, especially from Cardiff. Iron ore is associated with the coal, but most of the ore is now got from Spain. The chief town engaged in the iron industry is Merthyr Tydvil, though it has the disadvantage of being inland—a disadvantage, that is, now that the ore is brought from abroad. Swansea is engaged in the smelting of metals, chiefly copper brought from Spain. The industry arose there when copper and tin were brought from Cornwall, and the industry has persisted there, an example of industrial inertia, as is also Merthyr Tydvil.

Scotland.—*Physical Features.*—The three divisions of Scotland into Highlands, Midland Valley, and Southern Uplands are by no means of equal importance. The Midland Valley, containing

as it does practically all the coal of the country, contains also by far the densest population.

The largest area is that of the Highlands, which, with the exception of a coastal strip round the east coast and some of the valleys, is very infertile, and has to a large extent become the resort of the wealthy classes in search of game; deer forests and grouse moors occupy a large percentage of the area. North of the line separating Highlands from Lowlands occur the highest lands of the British Isles, the culminating point being Ben Nevis. North of this line, too, the coast on the west is much broken up by inlets and is studded with islands. The Outer Hebrides are formed of the oldest rocks in the British Islands. To the north are the Orkney and Shetland Islands, formed of Old Red Sandstone originally deposited in a great lake which extended from the mainland up to part of Shetland over the area now covered by sea. As the Shetlands are so near Scandinavia and face the fiords there, while they are remote from any of the older centres of population in Scotland, it is not surprising to find that they were, and still are, peopled by inhabitants of Norse blood. The same is true of the Orkneys.

The rivers of the Highlands drain into the North Sea and Moray Firth.

Beyond the facts already mentioned regarding the second division of Scotland—the Midland Valley—the most important physical fact is its extreme narrowness. It is not entirely lowland, and except geologically there is often little to separate it off from the third division—the Southern Uplands.

There is a general slope of the Southern Uplands to the Solway Firth and also eastwards; this is shown by the flow of the rivers, three to the Solway, and the Tweed and its tributaries to the North Sea.

The climatic difference between the east and west of Scotland must be kept in mind. This introduces an element of cross-classification, and makes it advisable to adopt the division of Scotland adopted by several eminent geographers.

1. The south-east of Scotland, including part of the Southern Uplands and of the Midland Valley. It contains the valley of the Tweed, famous, in spite of its distance from coal, for its wool manufacture, which it owes to its proximity to the raw material and to suitable water-supply. It also includes the Border district with its undying song and legend. Then there are the Lothians along the south of the Forth, fertile and well-tilled, where the proportion of wheat increases as the climate becomes drier from west to east.

Cities and Towns.—But the majority of the population is included in Edinburgh and Leith. Edinburgh owes its importance to its fortress, which commanded the great coast route from Northumbria to the Clyde. Its attractive situation and its climate, and the easy sea route from it to England and the Continent, have all enhanced that importance.

2. Western Scotland, with the greatest river of Scotland, the Clyde, and the largest town. The Southern Uplands are partly in this division also, and are mainly devoted to sheep-rearing. Lead, however, is mined at Leadhills. Dumfries is at the bridge-crossing of the Nith, on one of the easiest routes from England to Glasgow by the west coast. Most of the industry is centralised in Glasgow. It rose to importance from its situation with respect first to Ireland, and then to America. Its tobacco-merchants soon became famous. The coal-field of this district is associated with iron, not with oil shale, as in the case of the Midlothian coal-field. The iron, however, is practically exhausted, and iron has now to be imported for its extensive ironworks. Cotton and thread are important manufactures in Glasgow and its neighbourhood. The whole of the Clyde forms one of the greatest shipbuilding districts of Britain. Glasgow is a bridge town, and as the meeting-place of land and sea routes has an admirable situation. It has met the increasing size of ocean liners by deepening the Clyde, from 15 inches to 33 feet at one point, within a century and a half.

The west of Scotland, for a considerable distance north, comes into the Glasgow sphere of influence; this because the communication by water is so much easier than that by land.

3. The next area is the eastern part of Scotland north of the Forth, and south of the Highland Line. It contains the coal-fields of Fife and Clackmannan, and has several fertile strips such as the Carse of Gowrie north of the Tay. Dundee is the chief town, mainly occupied in jute manufacture. The population of this district is not, however, centralised in Dundee; a number of towns, both manufacturing and fishing, are to be found in the district.

4. The remainder of Scotland—that is, all above the Highland Line exclusive of the part which acknowledges Glasgow as its head—constitutes the fourth division. Much of it is highland and barren, but there is an important sill round the coast, containing nearly all the population. Aberdeen, the most important town, has a considerable hinterland, and therefore is an important commercial centre. It is also occupied in granite and fishing. The position of Inverness made it an important garrison town before the clans were reduced.

The chief railway routes in Scotland ought to be followed on the map, and the manner in which the physical structure has been utilised. The engineering difficulties have been considerable.

Ireland.—*Physical Features.*—The most important physical feature of Ireland is the great central plain. The division into four provinces is not wholly a geographical one. The chief river, the Shannon, is the longest in the British Islands. The rivers which flow to the south

coast present interesting features. Take the case of two of them. The probable history of the Suir and the Blackwater is this. The Suir, as a tributary of the Nore, worked its way along the more yielding rocks until it captured the head waters of the Blackwater. Meantime a longitudinal tributary of the Blackwater had been making its way steadily to the west, until it captured the head waters of the Lee and of the Bandon. The wind gaps which occur in the ridges confirm this supposition. A glance at the map will show how this explains the unusual course of the rivers.

Geologically the Highlands of Scotland are continued into Donegal, and the Southern Uplands of Scotland into County Down. The volcanic rocks to be found in Mull find their counterpart in Antrim. The Giant's Causeway corresponds to Fingal's Cave. Historically Dublin has grown as being on a good harbour opposite the Midland Gate in England. It gives easy access into Ireland. All the important towns are on the coast. The absence of minerals has prevented the centralising of the population in the towns. Except in the north the chief occupations are connected with the land. Most of the barley is grown in the south-east corner, thanks to climate influences. The rearing of stock and dairy farming employ much of the population, and Limerick and Cork are two important ports as outlets for these productions.

Cities and Towns.—In the north are the manufacturing towns outside Dublin. They are engaged in linen manufacture, getting their coal supply by sea. Flax is cultivated in the north. Belfast and Londonderry are the chief towns engaged in this industry. In spite of the disadvantage of distance from coal, Belfast has become one of the great ship-building centres of the United Kingdom.

In the south the position of Queenstown has made it an important port of call for the American mails, which are taken overland and then shipped across the Irish Sea.

The population of Ireland is largely Celtic, except in the north, where the colonisation of Ulster brought in a large infusion of Anglo-Saxon blood. But except in the manufacturing areas the population has continuously decreased for the last fifty years.

EUROPE

Physical Features.—Europe as a continent is not a geographical unit; it belongs to the great continent of Eurasia. The reasons for treating it separately are really historical. It is the most complex of all the continents. Its coast-line is the most indented of them all, due to the absence of any relation between the mountain structure and the ocean. Much of the area has been partly submerged, and the sea has entered the land in numerous inlets. This has had a great influence on the history of the people; sea-faring, fishing, commerce, have been stimulated, and the climate has been affected. The two great inland seas, the Baltic and the Mediterranean, present great contrasts. The Mediterranean was the home of the earliest civilisation in Europe, and there is a large population round its shores: the Baltic lands were occupied later, and are even yet sparsely populated. The Mediterranean is a deep, warm, intensely salt sea, with a steady current flowing into it from the Atlantic, and only a small counter-current flowing out near the bottom: the Baltic is shallow, is ice-bound in winter, is relatively fresh from the amount of river water flowing into it, and as a rule there is a current setting steadily out of it.

The most important features of the Continent are the great plain and the great mountain-chain which traverse it. The plain extends from France and the plain of England through the Netherlands and Northern Germany to the extreme east of Russia. It is possible to go from the west of France to the east of Russia without going through a single tunnel, and one may cross the Continent into the Caspian by river and canal.

To the south of the plain is the great chain of mountains, geologically continuous from the Pyrenees to the Caucasus. They are young mountains which were formed by pressure acting from south to north in general, and are ridged up against a much older worn-down range of mountains north to them. There is also a large highland area in the north-west comprising the Scottish Highlands and Scandinavia.

The climate of Europe is determined by two considerations: the range in latitude, which makes the climate colder from south to north, and the increasing distance from the sea as one goes eastward, making the climate steadily more extreme, *i.e.* more continental, from west to east. The rainfall also diminishes from west to east. The absence of a range of mountains like the Rockies on the west coast has had a profound influence on the climate. The extent of the inland seas has gone a great way in mitigating the tendency to continental rigour.

The general distribution of climatic zones, however, is on the whole from south to north and not from east to west, though with a tendency to the diagonal. First comes Mediterranean produce, next come wheat, orchards, and deciduous trees, followed by barley and rye, and birch and pine woods or forests. This has made it important that there should be no barrier to communication between south and north, in order that there should be means of communication between the climatic zones for the interchange of produce. At first sight this does not appear to be the case, for there is the

great barrier of the Alps interposed. But the Alps, though beneficial as a barrier protecting the south from the colder climate of the north, have in history proved to be by no means an insurmountable obstacle either to commerce or to invasion; hence the name "splendid traitor" applied to them.

Political Divisions.—The political boundaries of the countries and their physical divisions are not always the same. There can be no question about the boundary of an island, hence an island country like Britain has a much greater opportunity of undisturbed development than the continental countries. There can be about as little question about such boundaries as that between France and Spain, or, on the whole, between Italy and the rest of Europe. Similarly Scandinavia is by nature marked off from its neighbours, and the division into Norway and Sweden follows a natural geographical division. But there is no geographical reason for the existence of Portugal or of Switzerland. Again, the political boundary between France and Germany might easily have been elsewhere, and has been so many times in history. The claim that the natural boundary ought to be the Rhine has, however, no geographical sanction. Rivers, as has already been seen in the case of the British counties, are the very reverse of boundaries as a rule, except perhaps when there is much swamp on both sides of the river.

Other examples of political boundaries can easily be worked out.

We now come to take the political divisions in fuller detail.

France: *Relief.*—France has a situation with extraordinary natural advantages, as compared with most of the countries of the world. By sea it has a threefold outlook, to the English Channel, to the Atlantic, and to the Mediterranean. There is, however, a lack of natural harbours as compared with Britain.

The relief of the country is simple. There is a central plateau with low land practically all round it. To the south are the Pyrenees, with, between it and the central plateau, a gap of great advantage as one of the connections of the Rhone basin with the rest of France. In the south-east are the Alps.

The possession of navigable rivers is a valuable asset to the prosperity of France. The Garonne, the Loire, and the Seine, occur in ascending order of importance; though the Seine has the disadvantage of being liable to floods. The Rhone in spite of disadvantages, is also a useful waterway. Canals have an important share in the trade.

The climate, though it may be divided into at least five types, is essentially temperate, and permits of an unusually wide range of products. Wine and wheat are characteristic; the vine is cultivated on the warm, dry slopes on the edge of the higher land and in the warm river valleys. The vine can be cultivated nearly to the north coast, and beyond that limit cider is produced.

Industries and Towns.—There are many industrial centres, though some have to depend on imported coal from the Tyne. There is a Franco-Belgian coal-field on which stands Lille (with cotton and linen manufacture and with engineering works) and other towns. The port for this is Dunkirk. A smaller coal-field is at St. Etienne. Lyons is partly dependent on this coal for its silk manufacture. Iron is worked in the valley of the Moselle; the cotton industry flourishes on the Lower Seine.

The most important port for Mediterranean trade is Marseilles; it has a population of over half a million, and is one of the greatest seaports in the world. Other ports at the mouth of the other rivers are also important.

But the focus of French life is in Paris. It is the great road and railway junction, and dominates the whole of France.

Holland and Belgium are geographically a continuation of France. But they present noticeable contrasts. Belgium has an insignificant coast line, and cannot reach the sea by river except through foreign territory. Holland, on the other hand, is really the delta of the Rhine; it is largely below sea level; Belgium is not, and possesses considerable high land. But Belgium contains minerals, particularly coal and iron, and is therefore a great industrial country, with iron and engineering works and textile manufactures which support a dense population. Liége is occupied in engineering and Ghent manufactures cotton and wool. Antwerp at the mouth of the Scheldt is a great port. Brussels is the capital.

The Netherlands are entirely commercial and agricultural. Dairy farming and bulb culture are characteristic. The great ports, Amsterdam and Rotterdam, have as their hinterland the whole of the west of Central Europe. Amsterdam, thanks to hereditary skill, is the diamond-cutting centre of the world. The capital is The Hague.

Denmark is one of the very few peninsulas that point north. It has been important in history as a stepping-stone to Scandinavia and as a place of isolation and safety on the margin of civilisation.

Nowadays its position at the entrance to the Baltic gives it considerable importance, an importance not very materially affected from a commercial point of view by the construction of the Kiel Canal through German territory across the isthmus.

But its great importance is that it is educating the world in methods of dairy farming and showing how the people can be kept on the land. Besides Copenhagen not a town comes any-

where near the 100,000 limit of population. Iceland belongs to Denmark.

Germany is an empire comprising various kingdoms, grand duchies, and the rest, which have been welded into an empire for the sake of self-preservation. But the incorporation of Poland on the east (with the establishment of an unsatisfactory river boundary) and of Alsace-Lorraine on the west has been the source of considerable political trouble.

Relief.—The European plain covers the wide northern part, the narrower south rises to the Alps. There is a small sea-coast, most of it on the relatively insignificant Baltic. The rivers of North Germany show evidence of "capture" similar to the rivers of Southern Ireland. This has helped to spoil the hinterland of the rivers flowing into the Baltic. The Rhine, unfortunately for Germany, does not have its mouths in German territory. It is the greatest river highway in Europe. Germany has also, in the Danube, a great river outlet to the south-east. Means of communication by canal have been well developed, and the railway system, both for strategic and commercial reasons, has received particular attention. Only strategic reasons can account for the otherwise excessive railway development on the eastern and on the Belgian frontier.

The climate is much more continental than that of France, and in the north-east both climate and soil are unfavourable to agriculture. Along the upper Rhine and its tributaries lies the great wine land of Germany. Here also tobacco and wheat are grown. To the north and north-east it is chiefly rye, oats, and beet that are cultivated.

The minerals more than make up for the somewhat sterile soil in many parts. As is often the case, the worn-down old highland area against which the Alps were ridged up affords many metals. Coal is found on the European plain. Germany is rich in iron. It has thus the materials for great textile manufactures and engineering works. The chief industrial centres are in the Ruhr Valley tributary to the Rhine, in Silesia, and in Saxony.

Cities and Towns.—Berlin, the capital, is a typical bridge town, and is the largest manufacturing centre in Central Europe. Munich, famous for its brewing, is another bridge town, on the route from Vienna to Basle, and is on the route leading to the famous Brenner Pass. Magdeburg and Breslau are other examples of bridge towns. Hamburg is the greatest port, with a population of over a million. Its position on the Elbe is due to the configuration of the river at that point and to the easy communication from that point with Lubeck by rail and by canal. Bremen, on the Weser, a smaller river, with a poorer hinterland, comes next in importance as a port. Cologne stands at the head of ocean navigation on the Rhine, and its cathedral is one of the many attractions of tourist traffic up the river. The fortresses of Strassburg and Metz command the "gates" into France.

Considerations of space forbid any further detail.

Austria-Hungary: *Relief.*—Austria-Hungary is very largely a Danube land. It possesses also the head waters of the Elbe, the Oder, and the Vistula, which, in descending order of importance, are of great value to it. Into Italy it has access by the historic Brenner Pass; it has an inferior coast-line of which it makes the most; and by the Morava valley one of the oldest routes of the world leads into it through Serbia. Hungary is a central plain ringed round by the Carpathians; the west of Austria is alpine, the north-west is highland, only the north-east is plain.

The empire has been subject in ancient times to the irruption of alien races along the old routes, and has had to endure constant warfare. This explains the fact that the confusion of races and religions which reaches its height in the Balkans is felt here also, and is one of the great drawbacks to prosperity. It is only dire necessity that keeps them united, by however feeble a bond.

The climate is mainly continental, though there is a Mediterranean district. Hungary is largely agricultural, and produces excellent grain. Other products are wine and tobacco.

There is considerable mineral wealth in Hungary, mostly undeveloped. Austria is rich in minerals, especially in the highlands of Bohemia and Silesia. Cracow, on the northern frontier, is the chief town of a great salt area.

The recent annexation of Bosnia and Herzegovina had as one of its objects the extension of the Austrian coast-line, and the hope is that more European trade will henceforward flow through the newly-acquired ports and the other ports of the Dual Monarchy. At present Trieste is the Austrian and Fiume the Hungarian port; both require support from headquarters. The naval station is Pola, with an admirable situation for the purpose.

Cities and Towns.—Vienna, the capital of Austria, stands on the Danube at the entrance to the plain of Hungary. It is the converging point of many routes, and was originally chosen as a Roman camp because of its commanding position. The capital of Hungary, Buda-Pest, is also an old Roman camp, and is a bridge town. Prague is an important river port on a tributary of the Elbe, and is the centre of the great manufacturing industries of Bohemia.

The Balkan Peninsula, as has been said, is the storm centre of a great racial and religious conflict. In the autumn of 1913 the territory which had been adjusted on May 30, after

the war, had again to undergo readjustment after a resumption of hostilities. Naturally the countries are in a very backward condition.

The mineral wealth of the peninsula is undeveloped. In agriculture wheat is grown in Bulgaria, and maize in Serbia. In the Maritza valley roses are grown for perfume. In the parts under Mediterranean influence the usual Mediterranean fruits are grown, *e.g.*, small grapes for currants. Silk is important and so is tobacco.

The chief routes through the peninsula are (1) the great route from Asia through Constantinople and along the Maritza and Morava valleys; (2) from Salonika along the Vardar and Morava valleys; (3) from the Russian steppes at the north-east corner. Constantinople, commanding the sea route to the Black Sea, and the land route into Asia, has naturally a most important position. Salonika, without a good harbour, is important as being at the end of the Vardar Valley and therefore having a good hinterland as well as holding the key to a most important route. Similarly Belgrade at the end of the Morava route has a situation extremely satisfactory from every point of view except that its position on the frontier makes it not at all suitable for a capital city.

In Greece, Corinth on an isthmus is well suited for commerce, but the current of its canal is a great drawback. The importance of Athens was due to its harbour, its climate, and the absence of any industry to compete with its commerce. Its contact with other nations helped to give it its classical supremacy in the world of ideas.

Italy is structurally simple: the Alps confining it to the north and the Apennines stretching along the whole length of the peninsula, leaving level ground to the east or west as the mountains approach the opposite shore. Politically it includes the islands of Sicily and Sardinia, but Corsica belongs to France. The basin of the Po is an extremely important factor in the prosperity of the country, and it has been equally important in the history of the country—in the long struggle with Austria, for example. The other rivers of importance are the Adige, parallel to the Po, the Arno, and the Tiber, from which Rome ruled the world.

Climatically Italy is naturally a Mediterranean land, though locally there may be exceptions to the usual rule of wet winters and hot summers. The productions are characteristically Mediterranean fruits, the olive and the rest. Rice is valuable, and Italy produces the greatest quality of silk in Europe. As to minerals, it is sufficient to mention sulphur, associated with volcanic action, and the marble of Carrara.

The peninsula is too long in proportion to its breadth to make it easy to govern from a single centre, and therefore the unification of Italy has been a comparatively recent process. In fact United Italy is still feeling its way.

Italy presents extreme interest both from its present position and from its history. Rome was founded on hills to protect it from floods and from attack. Its distance from the sea made it safe from attack by water, while its position on the river enabled it to send forth its sons into the world. When the Mediterranean was the home of civilisation its situation was admirably central. Venice, with easy access to the sea, safe on its islands, and at the end both of land and sea routes, early rose to prosperity, though it is now out of the main current of commerce, which has been diverted to Genoa with the opening of the Suez Canal and the Alpine tunnels. But the main interest of Italian towns lies rather in an examination of their strategic position or in a consideration of them from historical or artistic standpoints.

The Iberian Peninsula.—It has been said that Europe ends at the Pyrenees, and this is in many senses substantially true. The Strait of Gibraltar has always made invasion from Africa easy, and the Moorish influence illustrates this. The Pyrenees are a real barrier in a sense that the Alps are not. The surface of the peninsula is high as a rule, and is ridged with parallel ranges of mountains. There is accordingly a lack of roads and of railways. There are only 9000 miles of rail as compared with 25,500 in France. There is also a lack of good harbours, and the rivers are equally useless for inland communication. The compactness of shape makes the climate more continental than insular, and the interior suffers from drought. These facts all make for a backward state of development in most parts. Minerals are abundant, and iron, copper, and lead are all exported in large quantities to Britain.

The agricultural products are generally those of the Mediterranean—olives, oranges, lemons, the vine, &c.

Madrid, the capital of Spain, is centrally situated, but has an unfavourable climate. Lisbon, the capital of Portugal, is on one of the few good harbours. Other good ports are Seville and Cadiz. Barcelona, the industrial centre of Spain, has a good artificial harbour. The industrial centre of Portugal is Oporto, with a suitable port for small shipping. Gibraltar, the key to the Mediterranean, is ideally placed and has an ideal structure.

Scandinavia.—This peninsula presents marked contrasts to the Iberian Peninsula and Italy. The points to be specially noted about it are: (1) The west coast composed of fiords and islands, which has made the Norwegian notable from early times as a fisher, explorer, and sea-rover. (2) The long range of mountains, barren or forested, which forms the major portion of the boundary between Norway and Sweden. This has had its share in confining the people to the

coast, with the result that no town of any size is to be found inland. (3) The fact that the west coast is ice-free. This is due to the high continental sill shutting off the cold arctic waters, and to the drift of warmer water from the Atlantic caused by the prevailing winds. Contrast with this the Baltic, which is not ice-free. The typical industries of Norway are fishing (*e.g.*, cod off the Lofoten Islands) and the manufacture of different products from the forest wood (*e.g.* matches). Sweden has the advantage of possessing iron-fields. Timber and dairy produce are typical products. Both countries lack coal, but have abundant water power which is bound to increase in importance.

Switzerland is the playground of Europe. Its scenery, mountain-climbing, winter sports, and health resorts attract increasing numbers of visitors. Its mountainous character has made it a haven of refuge, and the ease of access into it from various sides has caused it to shelter very different races, who, however, live in a harmony imposed on them by the necessity of union against outside powers. There is abundant water power. The typical industries are the manufacture of lace, silk, watches, chocolate, cheese, and condensed milk. As a rule these are articles which are of small bulk, and therefore are exported through other countries with less expense than bulkier articles.

Russia presents a complete contrast to all the other countries of Europe. In its size it is about nine times the size of the next largest country of Europe, and this of course is only the European section of the Russian Empire.

Relief.—The prevailing characteristic of the country is its monotony. It is a vast plain, and though it rises, in the so-called Valdai Hills, to over 1000 feet, the slope is so gradual as to be of little moment. The only steep slopes are on the margins of the rivers, which have worn deep beds for themselves. There is monotony of vegetation. It is true that there is great difference between the north and the south, but the transition is everywhere gradual. In the north are the tundras, frozen plains where frost practically never relaxes its grip. Next come forests of low trees, followed by enormous forests of evergreens. Then come forests of deciduous trees such as the oak and beech, succeeded by the Black Earth region, of great agricultural value. Still farther south are the steppes, wheat-growing to begin with, but passing into desert round the Caspian.

There are no varieties of climate; the level surface affords no obstacle to the passage of the prevailing winds, and there is therefore a slow change in passing from north to south. The climate is the most distinctly continental in Europe, with great range of temperature from summer to winter.

The rivers are slow and monotonous, often with very marshy borders which are a great obstacle to communication. But they are easily connected by canal, and this is an important matter for trade.

The monotony of the country has been reflected in the lives of the inhabitants. Everything has tended to depress and check enterprise and to increase the feeling of the insignificance of human life and action. Geography can point to Russia as a clear object-lesson on the reaction of environment on life.

Most of the people are engaged in agriculture; cereals are the chief product. Cattle are reared on the Steppes. Gold and silver and other metals are found, *e.g.*, in the Ural Mountains. Petroleum is important, and coal-fields have given rise to several manufactures.

Cities and Towns.—Petrograd, the capital, is on a marshy and very unhealthy site. It was founded by Peter the Great to be "a window looking out into Europe," and has a population of over two millions. Moscow is the old capital, on the converging point of all routes, and is important in manufacture and trade. Nijni-Novgorod, on the junction of the Oka and the Volga, is famous for its annual Fair. Odessa is the most important seaport on the Black Sea, exporting grain. Riga is a Baltic port, and in winter access to it is kept up by means of great ice-breakers. It exports timber, flax, eggs, &c.

Russia is in many ways isolated from the rest of Europe (by the character of its people, its climate and otherwise), and has a connection with Asia, of which the opening of the Trans-Siberian Railway is a symbol.

ASIA

Relief.—The first point to be noted about Asia is its vast size; it is more than four times the size of Europe, it is by far the largest continent, and contains nearly one-third of the total land surface of the globe. Compared with Europe it is exceedingly compact; the geographical grain of the land lies as a whole parallel to the coast, and does not strike across it as it does in Europe, to the great advantage of that continent. Notice the islands of the Pacific coast, which lie in festoons along the edge of the continent, enclosing a series of land-locked seas. They were originally part of the mainland, and have been separated by a series of fractures; the rocks of continental origin are seen on the outer shores: the inner shores, where the fractures took place, are naturally lines of weakness in the earth's crust, and are the scene of great volcanic action and of earthquakes. They form part of the "ring of fire" that girdles the Pacific.

The mountain system of Asia is the most stupendous in the world. The core of the system is the Pamirs, the "Roof of the world," to the north of India. From here mountain

chains run westward to reunite in the mountain knot of Armenia; another range passes to the north of Armenia as the Caucasus. Eastward from the Pamirs the mountains run in three great groups. The most southerly of these is the Himalayas, a continuation of which runs due south through the Andaman and Nicobar Islands and on through the Sunda Islands to the west of Sumatra. The Himalayas contain the highest point of the globe, 29,000 feet high. (Compare this with Mont Blanc, 15,781 feet and Ben Nevis 4406 feet by drawing them on a diagram.) North of the Himalayas is a range which under various names continues for about 3000 miles. Between the two great mountain chains is the plateau of Thibet. North of that again are the Thian Shan Mountains.

The great Russian plain is continued across the Urals as the Siberian Plain, which narrows as you go eastward.

There are three important peninsular sections of Asia, all with a southward trend—Arabia, India, and Indo-China.

A large part of Asia is a region of inland drainage; of this region the rivers flowing into the Sea of Aral are the chief.

The other rivers flow to the Arctic, to the Pacific, or to the Indian Ocean. They take their rise in the central plateau, and are of great length. Possibly they were established before the formation of the younger fold-mountains on the southern border, for the rivers which flow across them do not seem to shape their course according to the lie of these mountains. The upper reaches of the rivers flowing to the Arctic are free from ice in summer long before their lower reaches, and flooding results every year.

A very large proportion of the land is more than 1000 miles distant from the sea, and therefore the climate is of the most severely continental type, with the usual extremes of temperature. Most of the rain-bearing winds part with their moisture on the edges of the continent, with the result that the interior is largely desert, inhabited by a nomad population.

Climatic Zones.—Climatically Asia may be divided into five different areas, and these decide the flora and fauna of the continent. (1) The Arctic cold area. In one part of north-east Siberia the winter temperature falls to –60° F. The chief vegetation in this area consists of lichens and mosses, and the chief animal is the reindeer. (2) The Siberian temperate area, a land of forests, coniferous to the north and of deciduous trees farther south. Towards the east European species tend to die out and to be replaced by the trees of China and Japan. To the south the trees give way to grass lands, and these to (3) the central arid area, which has gradually become more desert. It is thought that the gradual dessication has led to the great invasion of the more fertile parts of Asia and Europe by vast hordes of men, thus giving an ultimately climatic reason for the Mongol invasion of China and Europe, and even for the downfall of Rome. The yak is the important animal of Thibet, as being the only animal that can subsist at an altitude fatal to other animals. The camel is used in the desert areas, and horses, cattle, sheep, and goats form the wealth of the nomads. (4) The monsoon area. This includes India, Indo-China, and the eastern coasts. Here, at different times in the different places, the land is under the influence of a rain-bringing monsoon from the sea for part of the year and of a dry off-shore monsoon for the rest of the year. The chief plants of economic value are cotton, grown largely in the Deccan; jute, in the Ganges Valley: tea (the cultivation of which has spread from China to India and Japan, and which requires hot summers, a good rainfall, and good drainage), grown on the hill-slopes; winter wheat; and rice and millet. One may say that these lands possess a "rice civilisation" in opposition to the "wheat civilisation" of Europe. There are great jungles, which are the home of the tiger, the elephant, &c. The buffalo is an important draught animal. (5) An area of the Mediterranean type, which stretches from the Mediterranean inland and merges into the desert area. Here the typical Mediterranean products are grown.

Asia is rich in minerals, but they are generally undeveloped. The richest tin mines in the world are in the Malay Peninsula. There are great coal-fields in China. Gold is found in many places, and the Yukon gold-field is probably a continuation of an Asiatic one. The precious stones of Asia are and have long been world-famous.

More than half the population of the world is to be found in Asia. It is commonly divided into three great races, of which the Mongolians or Yellow race are the most numerous. The population is concentrated in the monsoon regions; and the Ganges Valley, China, and Japan are amongst the most densely peopled areas of the globe. The peoples there are almost entirely occupied in agriculture. Mesopotamia, originally thickly populated, has, under Turkish misrule, fallen into decay, but the proposed restoration of irrigation may bring about a restoration of prosperity.

It is in Asia that all the great religions of the world have originated.

India, like Italy, has a great mountain barrier to the north. There are two great gateways through it, the Khyber and the Bolan Pass. Of these the Khyber has been the most important historically, and many irruptions of alien peoples have taken place through it. Hence the important strategic position of Peshawar. Once they were through the pass, the whole of the Indian plain was open to the

invaders. In crossing from the Indus to the Ganges the invaders would strike the river somewhere about Delhi, the present capital, and therefore in its neighbourhood some of the bloodiest battles in history have been fought. Delhi stands on the ruins of about ten cities. The position of Quetta on the western side of the Bolan Pass is a somewhat daring departure from the usual arrangement, for political reasons.

The opening of the Suez Canal gave a great impetus to trade. India has few good natural harbours. The reasons for the position of Karachi, Bombay, Madras, and Calcutta should be worked out. Bombay proposes to make use of the rainy monsoon to supply water-power on a large scale.

India contains many races differing in character and religion, and has never had any unity till such was imposed on it from without by a power whose base is the sea.

Other important British possessions in Asia besides India are Aden, commanding the route to India; the southern part of the Malay Peninsula, with the island of Singapore, whose town is one of the most important ports of call in the world; North Borneo; and Hong-kong.

Japan and **China** differ in many respects. Japan is highly mountainous and volcanic, with steep slopes into valleys which are comparatively low and form easy passes. It is liable to earthquakes. One of the earthquake centres is the Tuscarora Deep off its coasts, the greatest abyss in the world. A current, the Kuro Siwa, like the Gulf Stream, modifies the climate. Japan has within comparatively recent times become a most progressive power.

China contains extremely large and fertile plains; in the north these are covered to a depth of hundreds of feet with a porous deposit called loess, supposed to be formed from dust blown from the arid interior of Asia. The Yang-tse-kiang is a most important water-way, the Hoang-ho is of little importance in that respect. It has changed its course many times in history, and one flood gave rise to the greatest disaster in human history, several million lives being lost.

Many foreign residents occupy the Open Ports of China.

The Awakening of China seems to be now begun.

AUSTRALASIA

Australia.—The Malay Peninsula of Asia is the commencement of a line which curves round along several islands to the island of New Guinea and the continent of Australia. Wallace's line, called after its discoverer, runs to the south of Borneo and between the islands of Bali and Lombok. It divides the islands into two groups, the one of which has fauna distinctly Asiatic in type; the other is as distinctly Australian. With the exception of the continent round the South Pole, at present being explored, Australia was the last of the continents to be discovered. With its discovery are associated the names of Tasman and Captain Cook in particular. It was at first used by the British as a convict settlement; the discovery of gold led to a great rush of settlers. Since then its prosperity has been steady, depending on gold and other metals, and on its enormous production of wool. It is now proposed to experiment with the cultivation of cotton in Queensland.

None of Australia reaches the Equator, but the Tropic of Capricorn crosses it at about its widest part. New Guinea to the north is within the equatorial rain-belt and has rain at all seasons. The equatorial rains reach the northern part of the continent in summer and provide a sufficient rainfall. The south-west corner of West Australia and Victoria come within the range of the wet westerly rains in winter-time. But the bulk of the continent is in the trade-wind area, and any moisture that is provided by this wind is caught by the eastern highlands; this accounts for the arid interior. There are three great divisions of the continent—a western plateau, a great plain stretching across the centre, and an eastern highland area. A large part of the interior is an area of inland drainage. Much of the area was once submerged, but the continent as a whole is part of a plateau, only part of which is now above sea-level. The land area was once much greater than it is at present. The Great Barrier Reef along the north-east coast is a distinct evidence of submergence. The coast, as a rule, is regular, and on the whole there is a deficiency of good harbours, though that of Sydney is magnificent.

The only river of importance is the Murray with its tributaries. The others form floods in rainy weather and are a mere succession of stagnant pools in dry weather.

The trees are naturally such as are adapted to drought, such as the eucalyptus. The typical animal is the kangaroo; the introduction of the rabbit has proved disastrous.

The population is naturally concentrated mainly round the south-east coast. The chief occupations are those connected with sheep and cattle, wheat-growing, the cultivation of the vine in Victoria, and gold-mining.

The country is a federal commonwealth within the British Empire. The new capital is to be Canberra in the federal district purchased from New South Wales in 1911.

New Zealand.—The most striking feature of New Zealand is the mountain backbone running from the south-west of South Island through both islands, and attaining an elevation in South Island sufficient to give glaciation greater than that of Switzerland. In North Island there is much volcanic action, and connected with this is the Hot Lakes District. The

climate is healthy and equable, and is warmer than that of Britain from the greater nearness to the Equator. The islands feel the full force of the Brave West Winds, and there is therefore more rain on the west than on the east side of the islands. Rivers are very numerous, but are mostly mountain torrents, and there are many lakes. Nearer the Equator the land is beyond the influence of the Roaring Forties except in winter, and, having a "Mediterranean" climate, grows the usual fruits of that region. Sheep are reared on the Canterbury Plain in South Island and elsewhere. Wool, frozen meat, agricultural products of various kinds, and gold are the chief exports. Most of the trade (almost 80%) is with the mother country.

AFRICA

Relief.—Africa, three times the size of Europe, is structurally the simplest of the continents. It is compact in shape. In the north the Atlas Mountains are part of the great mountain system of Europe, and have been separated from it by the formation of the Strait of Gibraltar and by the subsidence of that part which originally stretched through Malta and Sicily into Italy. Next to these mountains comes the Sahara, and beyond the Sahara the whole of the continent is a great plateau. This plateau descends by a series of steps, formed by great fractures in the earth's crust, to the sea. Two great Rift Valleys run roughly north and south through the eastern half. In these the crust has fractured along two parallel lines, and the land between has sunk. The Eastern Rift passes out of Africa, along the length of the Red Sea, and up to the Dead Sea and the Jordan; the Western Rift contains Lakes Albert, Edward, and Tanganyika. Outside the Atlas, the only real mountains are volcanic in origin, mostly extinct, though near Lake Tanganyika is a group of active volcanoes, at the farthest known distance from the sea of any volcanoes. They evidently have a connection with the Rift Valley.

Equidistant from the farthest north and south points runs the Equator. But most of Africa lies in the northern hemisphere. There is a gradation of climate from the Equator in both directions. At the Equator itself there are the equatorial rains and the consequent tropical forests. North of that is the region of summer rains giving the savanna lands of the Sudan, rich park lands with tropical trees and fruits, and with such animals as the antelope, zebra, giraffe, lion, leopard, elephant, &c. Then succeeds the Sahara Desert in the trade-wind area, and next the region of Mediterranean climate and produce. The same gradation is observable towards the south, but as the continent is narrower in the south, everything is on a smaller scale; the Kalahari Desert, for instance, cannot be compared to the Sahara, which is comparable in size to Europe.

All the great rivers take their rise in the region of great rainfall. Only one important river flows eastward. Perhaps the most famous in history is the Nile, the centre of one of the ancient civilisations of the world. Along its banks is a ribbon of very fertile soil which owes its existence entirely to irrigation. The characteristic and for long most puzzling feature is the annual flood, which is due to the summer rains in the highlands of Abyssinia. The waters of these rains take months to reach Egypt and begin to arrive in the very hottest season. The ordinary perennial flow of the river comes from the region of equatorial rainfall; most of this is lost by evaporation long before the mouth of the river is reached. The control of the floods by means of barrages has greatly increased the productivity of the region. The chief crops are cotton of excellent quality, wheat, and other cereals. Egypt is under British control, a control of greater importance since the opening of the Suez Canal.

The greatest river is the Congo, whose estuary has been traced for some distance in the bed of the ocean. Unfortunately the structure of Africa causes great rapids where the river reaches the edge of the plateau near the end of its course, and therefore the river is not navigable from its mouth upwards. A railway to Stanley Pool avoids the rapids, and from there the river is navigable for about 1000 miles. The country is generally densely forested, and the main products are rubber and ivory.

The Niger is the third great river. It rises in a region of heavy rainfall, though its course takes it through the savanna lands of the Sudan. It is of great value as a highway, but the intricate nature of its delta has caused it to be avoided by a railway from Lagos to a point farther up the river. Palm oil and rubber are important products, and the cultivation of cotton is steadily increasing.

The Zambesi flows through an area that is already prosperous, and is increasing in prosperity. A large part of the area is suitable for occupation by Europeans. The Victoria Falls are a striking feature of the Upper Zambesi.

The last important river is the Orange River with its tributary the Vaal.

The mineral wealth of Africa is very great. It produces more gold than any other continent. The most important gold-field is the Rand, in the Transvaal, but gold is also found elsewhere.

Diamonds are found in the British provinces of the Cape of Good Hope, the Transvaal, and the Orange Free State. The discovery of gold and diamonds has attracted a large white population.

The islands of Africa are few. The largest, Madagascar, does not stand on the continental shelf, so that its connection with the mainland

is practically one of proximity only. It is a French possession, as also is Reunion beyond it. Mauritius and Zanzibar are British. The other islands are off the north-west coast.

Communication.—The methods of communication are an interesting reflex of the various conditions of the continent. In the equatorial forests native porterage is largely employed along the tracks through the forest where only one man can walk at a time. The canoe, and nowadays on the larger rivers and on the lakes the steamer, are invaluable for this region. In the desert the camel caravan is the essential means of transport. In most parts of Africa where roads are most necessary their construction is a matter of extreme difficulty, and this has made the railway even more important than it would otherwise have been. Railway construction has also been a difficult business owing to the step-like nature of the plateau. In South Africa the railway, connecting towns far apart with each other and with the coast, is vital to the prosperity of the country. The line is steadily creeping northward, and has now passed into the Belgian Congo State. The railways ought to be examined on the map and their economic justification explained.

Except in South Africa and on the Nile, practically all the towns are arranged in a ring round the rim of the continent.

Almost the whole of Africa has been partitioned among the European powers. This has been effected chiefly during the past thirty years. It was due to the discovery of the commercial value of the continent, and its possibility is a striking comment on the low state of civilisation and the want of cohesion of the native inhabitants.

AMERICA

South America: *Relief.*—South America may usefully be compared and contrasted with Africa. They both lie largely in the Tropics or in subtropical regions. But note that the Equator cuts South America very much nearer the northern end, so that none of it is north of the Tropic of Cancer. On the other hand, much more of it is south of the Tropic of Capricorn. Like Africa, it is very compact and has few islands. Its mean elevation is also much the same, about 2000 feet. But it contains a much larger amount of land below 600 feet, and it has its highest land to the west. The winds from the ocean have therefore easy entrance to the heart of the land, and this has a considerable effect in modifying the climate, which is much less "continental" than in the case of the other continents. There is no desert area to the north of the Equator, since none of the land is in the trade-wind region. South of the Equator the south-east trades create a desert region much less in extent than in the case of Australia, where the moisture is deposited at once on the mountain barrier to the east. Farther south come the Roaring Forties which bring plentiful rainfall to the western part. The Llanos of the north and west of the Orinoco, the Campos of Brazil, and the Pampas round the Plate basin are characteristic savanna lands like those of Africa. The Selvas of the Amazon basin, in the region of equatorial rains, are dense tropical jungle.

The rivers are one of the great means of communication; they are navigable for long distances inland, steamers can go for about 3000 miles up the Amazon, and the other rivers are proportionally good. The greatest volume of trade passes along the rivers of the Plate basin. The Amazon, being, like the Congo, an equatorial river, receives an enormous rainfall. It discharges into the sea a greater volume of water than any other river in the world. The other important rivers ought to be followed out on the map. The configuration of the country naturally gives them all, practically without exception, an eastward course.

The products vary with the varying climate; rubber from the Amazon Valley, and coffee, sugar, and tobacco elsewhere are the chief products of the tropical lands. Cotton is important in Brazil. The cinchona (for quinine) is found in Peru and Columbia. Wheat is grown in immense quantities in the Argentine, which is also noted for its horses, cattle, and sheep. Atacama, thanks to its desert nature, is a great source of nitrates.

The mineral wealth has long been famous, and was the chief attraction for the Spanish and Portuguese conquerors. But with the exception perhaps of the silver of Bolivia, the output is now relatively unimportant. Perhaps the silver mine of Potosi has been the most productive in the world.

Development.—Though South America is not far short of being sixty times the size of the British Isles, it contains barely double the mileage of railroads. Most of the railway development is in the Argentine. The Atlantic and Pacific have recently been connected by a line from the Plate estuary to Valparaiso, the chief port on the Pacific coast of South America. The railway system is being extended, with the help of British capital, but the paucity of railways points to a backward state of development, due largely to the unsettled political state of the republics, where revolutions are far from uncommon. Britain, France, and the Netherlands each possess part of the Guianas, but otherwise the states are independent. With the exception of the Portuguese Brazil and part of the Guianas, Spain was from the time of the discovery and conquest on to the nineteenth century master of the whole of the continent, and used to drain its resources to further the

European schemes of the conqueror. In the end, as the result of many struggles, the Spanish yoke was thrown off.

The continent shows an extraordinary mixture of races. Some pure-blooded races exist, but the great majority of the inhabitants are of mixed race, descended from native South American Indians, Spanish, Portuguese, and other European nations, negroes from Africa, Hindus from India, and others.

The West Indies.—The name, as also the use of the word Indians to describe the aboriginal inhabitants of America, perpetuates the mistaken idea of Columbus that in his famous voyage of 1492 he had reached the continent of Asia. In undertaking this voyage, which stood a good chance of taking place under English auspices, Columbus showed his genius in two ways. First, he boldly abandoned the idea then prevalent that there was a large solitary island in mid-Atlantic which might serve as a half-way house on the way to India. This idea caused other navigators to waste time fruitlessly cruising about in mid-ocean in a vain search for an island that was non-existent. Secondly, he formed the plan of utilising the trade winds for his outward voyage and then working his way northward and taking advantage of the westerly winds for his return. The success which crowned his intellectual as well as physical courage marks a new era in the history of the world. Of the islands thus discovered little need be said. They are mountainous and volcanic, and are noted for their tropical productions, such as sugar and bananas.

Central America is mainly mountainous or plateau land with the trend of their structure not north and south as in the rest of America, but east and west. It lies within the Tropics, and receives abundant rain, especially in summer. Tropical plants are grown, and on the higher land the climate is cool enough to allow of the cultivation of wheat and other temperate region products.

The chief interest of Central America at present, however, is the construction of the Panama Canal by the United States over land purchased from the Government of Panama. The length of the canal is 50 miles, and it is now in regular use.

North America in the north-east makes its nearest approach to Europe, and this explains its discovery by Scandinavian voyagers long before the time of Columbus. In the extreme north-west it approaches very near Asia, and this accounts for the Russian occupation of Alaska, which was eventually bought from that power by the United States.

Relief.—The size is twice that of Europe. In the west a great system of mountain chains under various names stretches along the whole length. The eastern highlands are of much smaller elevation. In geological times there has been a considerable alteration in level. The submergence of the land along the eastern coast has resulted in rocky coasts with many deep inlets that are of great value. North and South America present many resemblances in structure, and many contrasts in climate. The climate is dependent on the usual world conditions as modified by the configuration of the land. Thus there is the usual transition from tropical to Arctic temperatures; and the usual north-easterly winds in the south and westerly winds farther north. The continental nature of the climate is seen in the curving of the summer isotherms over the land, carrying the heat farther north over the inland area than over the coastal regions. The presence of the Rockies on the western seaboard means a great precipitation of moisture there and a consequent dryness of the westerly winds over the plains. The submergence of the Gulf of Mexico has meant that there is a much greater area under the influence of moist winds from the ocean (of a monsoon type) than would otherwise have been the case. Although much of the interior is somewhat arid, remarkably little is actually desert. The extraordinary scenery of the Grand Canyon of the Colorado is due to the absence of rain to wear back the river-banks, which have been cut straight down through horizontal strata to the depth of a mile.

The Ice Age in North America has resulted not only in the formation of great lakes that are an important means of communication, but in the deposition of soil over enormous areas, a deposition which accounts for the great fertility of the land.

Canada, occupying the northern part of the continent, is separated from the United States by a boundary which is for a great part of its length merely a line of latitude, and therefore there are no regional reasons for considering it apart from its southern neighbour. But such facts as the failure of the attempt to establish commercial reciprocity between the two justify their separate treatment.

A large part of the area will always be incapable of cultivation, from cold in the north, from the height and steepness of the mountains in the west, and from the poverty of the soil in the Laurentian plateau. But the great plains with their fertile soil are one of the great wheat areas of the world. Where the rainfall is insufficient for wheat, there are great cattle ranches—*i.e.* to the east of the Rockies. The eastern region of Canada is forested, and lumbering is one of the most important occupations. The same applies to the forested Pacific slopes of the Rockies.

It has been suggested to construct a railway to a port on Hudson Bay for the export of wheat from Manitoba. At first sight this seems a most absurd route to choose; but this merely

indicates how unsatisfactory maps are as compared with a globe as an accurate representation of the world. If you take a globe and stretch a piece of thread as tightly as possible between Winnipeg and Liverpool, the reason for the suggested route will be obvious. Of course the bay is frozen for most of the year, but it is ice-free at the very time when the pressure of traffic commences. A greater objection is the shallowness of the bay, which would prevent ocean-going steamers from approaching near the land.

Of the minerals of Canada the most important are gold, silver, copper, iron, and coal. The mineral wealth is as yet largely undeveloped. The discovery of gold in the Yukon territory led to a great "rush" in 1898. British Columbia also contains several gold-fields.

Other great sources of wealth are fruit, dairy produce, and fishing.

Canada is well served by its great water-ways, both lake and river. The Great Lakes are ice-bound in winter. The lakes have been made still more useful by the construction of canals. There is also an excellent system of trans-continental railways. The chief towns owe their importance mainly to commercial causes. They have sprung up not as manufacturing centres, but as centres for the collection and distribution of products. An excellent exercise, therefore, is an examination of the map to discover the reasons for the importance of the sites.

The United States, separated by a political boundary only from Canada, is also separated from Mexico on the south by a line which is not determined by geographical considerations. This latter republic is in a state of political unrest and consequent want of development.

The United States possesses great natural advantages. To the north-west are great cattle ranches, and therefore Chicago, well placed for both natural and artificial transport, has become the world's greatest meat purveyor. Where the climate becomes moister, wheat in the north and maize farther south are cultivated. In the wheat lands Minneapolis has grown up as a flour-milling centre because of the proximity of St. Anthony's Falls, which supply water-power for the mills. On the eastern lowlands tobacco in the north and cotton in the south are the chief crops. One of the greatest coal-fields in the world has Pittsburg as its chief town. Here too are oil wells and iron ore, and further supplies of ore are brought from the shores of Lake Superior by water. This is the only great town that owes its existence to the presence of coal; all the others owe their prosperity to conditions favouring commerce.

The Mississippi and its tributaries form a great north and south water-way, but it has been an obstacle to be overcome in the east and west railway communication. The other obstacles are of course the barriers of the Rockies and the Alleghanies. The Hudson with its tributary the Mohawk offers a means of circumventing the latter barrier; hence the importance of New York, and its population of over four million. At the point where the Rockies are crossed San Francisco with its magnificent harbour has become a great port.

The water-power supplied by the rivers of New England has given rise to a good deal of cotton manufacture. The humid atmosphere, as in Lancashire, is suitable for this industry.

In addition to coal and iron, gold is found in California and Alaska, silver in Nevada, and copper near Lake Superior and elsewhere.

The United States has had a comparatively short history. In the beginning geographical factors played a very considerable part in the struggle between the British and French. The development of the country has been extremely rapid and successful. Two of the great problems which it has now to face are the growth of trusts and the "colour" problem. Even these, to some extent at least, have a connection with geography in its widest sense.

G. S. Dickson, M.A., B.Sc.

COURSE OF READING

Maps and Atlases.—All serious study of geography must begin with large scale maps. The sheets of the 1-inch Ordnance Survey, obtainable in various forms, make an admirable beginning, while for many purposes Bartholomew's Reduced Ordnance Survey Sheets are useful. As the British Isles contain only a limited number of types of scenery, these maps should be supplemented by others, including areas of different character. The sheets of the Swiss Topographical Map are singularly beautiful specimens of cartography, and those of the higher areas are invaluable for the study of mountain scenery. A volume published by the U.S.A. Geological Survey as *The Interpretation of Topographic Maps*, by Atwood and Salisbury, not only contains specimens of sheets showing regions of special interest, but also very careful descriptions of the maps, of great assistance to the beginner. For use with our own Ordnance Survey Maps the following may be recommended: *Maps: How they are made and how to read them*, by H. N. Dickson (a small pamphlet, published at London, 1912); Elder-

ton, *Maps and Map Drawing* (London, 1906), and Newbigin, *Ordnance Survey Maps: Their Meaning and Uses* (London, 1913), both also small works.

Atlases, if good, must always be rather costly. The numerous cheap issues for schools are not, as a rule, adapted for anything but somewhat elementary work, but *Longmans' New School Atlas*, edited by Chisholm, and somewhat more expensive than the majority, may be recommended. A good German atlas, remarkably cheap, is Lehmann u. Scobel, *Atlas für höhere Lehranstalten*, which has some excellent physical plates. For general use Bartholomew's *Citizen's Atlas*, of which there are also cheaper issues, is as good as any. The student will not fail to consult the *Atlas General Vidal-Lablache*, a very fine French work, and Stieler's *Hand Atlas*, now available in an English edition. Among special atlases mention may be made of Bartholomew, Buchan, and Herbertson's *Atlas of Meteorology*, with introductory text, and Bartholomew's *Atlas of the World's Commerce*. A small commercial atlas, with a considerable amount of introductory text, is Bartholomew's *Atlas of Economic Geography*, with introduction by Lyde.

General.—The following small books may be recommended as giving some general notions on geography from the modern standpoint: Keltie, *History of Geography* (London, 1913) and *Applied Geography* (2nd edition, London, 1908); Newbigin, *Modern Geography;* Gregory, *The Making of the Earth;* Cole, *The Growth of Europe*. The last three are all in the Home University Library, and have references. A much larger book, which treats of a considerable variety of subjects, is Semple, *Influences of Geographic Environment* (London, 1911).

Physical Geography.—Small books on the subject are Mill's *Realm of Nature* (2nd edition, London, 1913), and Newbigin, *An Introduction to Physical Geography* (London, 1912), the latter with references. The most comprehensive book in the English language is perhaps Salisbury's *Physiography* (London, 1907), but those who can read French should not fail to consult de Martonne, *Traité de Géographie Physique* (2nd edition, Paris, 1914), with very full references and some admirable pictures and diagrams. Among special subjects meteorology and climate are very important. Small books are Fowler and Mariott, *Our Weather* (1912), and Dickson, *Climate and Weather* (Home University Library, 1911). Part of Hann's great book has been translated by Ward as *Handbook of Climatology* (1903), a work of great importance. A number of good exercises in physical geography will be found in Simmons and Richardson, *An Introduction to Practical Geography* (1907), while for the working of problems a *Nautical Almanack* such as Brown's, published annually at Glasgow, is indispensable. The Royal Geographical Society's *Hints to Travellers*, periodically brought up to date, is full of useful material.

Commercial Geography.—The best general text-book is Chisholm's *Handbook of Commercial Geography*, brought up to date at regular intervals; there is also a smaller book by the same author. Consult also J. R. Smith, *Industrial and Commercial Geography*, and McFarlane, *Economic Geography* (London, 1914). In connection with economics, the rich storehouse of material to be found in Government Blue Books and colonial and diplomatic reports must not be neglected.

Regional Geography.—The most comprehensive and scientific single work in English is *The International Geography*, by seventy authors, edited by H. R. Mill, but it is somewhat stiff reading. A delightful book, now somewhat out of date, is Reclus' *Nouvelle Géographie Universelle* (Paris, 1878–1895), the English edition of which may sometimes be picked up second-hand. Stanford's *Compendium of Geography and Travel*, thirteen volumes, by various authors, is very useful. A series, entitled *Regions of the World*, has been published under the editorship of Mackinder, of which the most notable volumes are the editor's *Britain and the British Seas* (2nd edition, Oxford, 1907) and Partsch's *Central Europe* (1903). The volumes are obtainable separately, and cover the world at large. A new series, of which one volume only has as yet appeared, is by Lyde, this first volume being *The Continent of Europe* (London, 1913). For the British Islands in detail, in addition to Mackinder's book mentioned above, we have Geikie, *The Scenery of Scotland* (3rd edition, London, 1901); Avebury, *The Scenery of England* (1902); the *Cambridge County Geographies*, small volumes, one for each county, appearing under the editorship of Guillemard; and many school books by Herbertson, Mackinder, and others.

Those desirous of beginning the detailed study of any region of the world will find it convenient to consult the *Statesman's Year-Book*, which is published annually, and not only gives short accounts of all the countries, but also references to the chief official and other publications upon each. Finally, full lists of books, with bibliographic details, will be found in the *Guide to Geographical Books and Appliances*, prepared by members of the Geographical Association (London, 1910). Serious students will find it desirable to join a geographical society, such as the Royal Geographical Society, London, the Royal Scottish Geographical Society, Edinburgh, or the smaller bodies which exist in almost all the larger towns of England. For teachers, membership of the Geographical Association offers many advantages. The publications of the three bodies named, which are respectively *The Geographical Journal*, *The Scottish Geographical Magazine*, and *The Geo-*

graphical Teacher (the first two monthly, the last once a term), give descriptive accounts of recent books and other geographical publications.

Books of Travel may be regarded as falling into two great sets, those which are read for the sake of their authors, and those valued because they give pleasant or useful accounts of distant places. The classification is not scientific, for the same book may fall into both categories, but there is nevertheless a real distinction between the works of the pioneer travellers, like Marco Polo, Livingstone, and so forth, and those of the many authors who give interesting descriptions of unfamiliar places without attaining great eminence either as writers or as individuals. In the following lists we shall mention first the great travellers who have first penetrated or described unknown regions, and second the writers who have supplemented or elaborated the observations of the pioneers.

Europe.—Travel books in the strict sense scarcely exist in the case of this continent, but the student will not neglect such works as Borrow's *The Bible in Spain*, whose interest is literary rather than geographical; Dufferin's *Letters from High Latitudes*, and so forth; while some of the recent books on little-known parts of the Balkan Peninsula, such as Miss Durham's *High Albania*, and books like Bisiker's *Across Iceland* (1902), may be regarded as coming under the head of travel and exploration.

Asia.—This continent has had an enormous amount of attention devoted to it. The student will begin with Marco Polo's *Travels*, and follow it up with Bernier's *Travels in the Mogul Empire* (1656–68), the Abbé Huc's *Recollections of a Journey through Tartary, Tibet, and China in* 1844–46, Palgrave's *Narrative of a Year's Journey through Central and Eastern Arabia in* 1862–63, Burton's *Personal Narrative of a Pilgrimage to El-Medina and Meccah*, and Prejevalsky's accounts of his two great Asiatic journeys, as set forth in *Mongolia, the Tangut Country, and Solitudes in Northern Tibet* (1876), and *From Kulja across the Tian Shan to Lob-nor* (1879).

Coming down to more recent times, we have Sven Hedin's journeys, as described in *Through Asia* (1898), *Adventures in Tibet* (1904), *Trans-Himalaya* (1909). The same author's *From Pole to Pole* gives accounts, in simple language, of travel generally. Quite popular in style, but pleasant and attractive books, are those written by Mrs. Bishop (Isabella Bird) on her journeys in various parts of Asia—*e.g. The Yangtze Valley and Beyond* (1899), *Unbeaten Tracks in Japan* (1900), *Korea and Her Neighbours* (1898), &c. One should read also Younghusband, *The Heart of a Continent: Manchuria, Turkestan, and the Pamirs* (available in a new cheap edition, 1908); Waddell, *Lhasa and Its Mysteries* (1905).

Those interested in natural history should not fail to read Wallace's *The Malay Archipelago*, and other books which will also appeal to them are Nordenskiöld, *The Voyage of the "Vega" round Asia and Europe* (1881); Alcock, *A Naturalist in Indian Seas* (1902); Forbes, *A Naturalist's Wanderings in the Eastern Archipelago from* 1878 *to* 1883.

Africa.—Here Herodotus makes a good beginning, and may well be followed by Sir Harry Johnson's *The Nile Quest* (1903), which gives an elaborate historical survey. Mungo Park's *Travels in the Interior of Africa* must not be neglected before passing on to Livingstone and Stanley. All Livingstone's books should be read—*First Expedition to Africa*, 1840–56; *Second Expedition to Africa*, 1858–64; *Last Journals in Central Africa* (1874)—and they will naturally lead up to Stanley's *Through the Dark Continent* and *In Darkest Africa*. Speke, *Journal of the Discovery of the Source of the Nile* (1863), must also be read, together with Thomson, *To the Central African Lakes and Back* (1881), and *Through Masai Land*. Note also Baker, *The Albert Nyanza, Great Basin of the Nile, and Exploration of the Nile Sources*, and Burton, *The Lake Regions of Central Africa* (1860).

Of later works we can only give a selection. All Miss Mary Kingsley's books are worth reading. See *West African Studies* and *Travels in West Africa*. Alexander Boyd, *From the Niger to the Nile*; Sir H. H. Johnston, *The Congo, from Its Mouth to Bolobo*; Moore, *To the Mountains of the Moon*; Drummond, *Tropical Africa*, are also interesting. Compare also R. Brown, *The Story of Africa and Its Explorers* (1893).

America.—For this continent some of the original Spanish accounts, as available in translation in the volumes published by the Hakluyt Society, form the best introduction. See also Fiske, *Discovery of America: With some Account of Ancient America and the Spanish Conquest* (1892, published at Boston), and Payne, *History of the New World called America* (1892); also Prescott, *History of the Conquest of Mexico* (1843).

Of travel books in the strict sense there are many, the more recent examples mostly dealing, as was to be expected, with South America. Very attractive on account of their style are the following: Belt, *The Naturalist in Nicaragua* (1874); Whymper, *Travels among the Great Andes of the Equator* (1892); Hudson, *The Naturalist in La Plata* (1892) and *Idle Days in Patagonia* (1893); Agassiz, *A Journey in Brazil* (1869); Bates, *Naturalist on the River Amazonas* (1892); Lumholtz, *Unknown Mexico* (1903), &c. Darwin's *Voyage of the "Beagle"* also gives much space to South America.

Australasia and the Oceanic Islands.—There is not a great deal of first-rate importance in regard to these regions. Captain Cook's *Voyages* will naturally form the starting-point. See

Low, *Captain Cook's Three Voyages round the World* (1897), and Thynne, *The Story of Australian Exploration* (1894). Warburton, *Across the Western Interior of Australia* (1875), indicates the conditions found in Australian exploration in earlier days.

For the islands R. L. Stevenson's *Letters from the Pacific* should be read. See also Mrs. Bishop, *The Hawaiian Archipelago*, and Beatrice Grimshaw, *Islands North-East of Australia* (1883) and *In the Strange South Seas* (1907); also Haddon, *Head Hunters: Black, White, and Brown* (1901).

Arctic Regions.—Of recent years the greatest output of travel books has been in connection with polar regions, where alone real adventurous travel in unknown areas remains possible. In the case of the Arctic area, Greeley's *Handbook of Polar Discoveries* (1886), with a useful bibliography, should be consulted for the history of discovery. The following is a selected list of the more important or more interesting books on the subject; for fuller information Greeley's bibliography should be consulted: McClintock, *Narrative of the Discovery of the Fate of Sir John Franklin;* Markham, *The Great Frozen Sea*; Markham, *Franklin and the North-West Passage;* Parry, *The North-West Passage;* Payer, *New Lands within the Arctic Circle* (1876); Greeley, *Three Years of Arctic Service;* Nansen, *The First Crossing of Greenland* (1888); Nansen, *Farthest North: The Voyage of the "Fram"* (1897); Peary, *Northwards over the Great Ice* (1898); ——, *Nearest the Pole* (1907); ——, *The North Pole* (1910).

Antarctic.—The list of travel books in this case is somewhat shorter, for the motive which prompted so much Arctic exploration, that of finding a route to India, was absent here, and active Antarctic exploration is of late date. Mill's *Siege of the South Pole* (1905) gives a full historical account, with a bibliography. To this book it will be sufficient to add the following: Nordenskiöld, *Antarctica: or, Two Years amongst the Ice of the South Pole;* Scott, *The Voyage of the "Discovery"* (1905); Shackleton, *The Heart of the Antarctic* (1909); Amundsen, *The South Pole* (1912); *Scott's Last Expedition* (1913); Priestley, *Antarctic Adventure: Scott's Northern Party* (1914); Mawson, *The Home of the Blizzard* (1914).

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GEOLOGY

Introduction.—The science of Geology deals with the crust of the earth. Interest in this study may be aroused in various ways. A short walk may bring one to a quarry or a cliff, and the formation of the rock may arrest attention and ask explanation; a railway cutting may start the same line of thought; the stones of a sea beach or of a river bed may be picked up and some peculiarity force itself on one's notice; the finding of a fossil may stimulate the imagination. Or it may be that one begins to wonder why the landscape is just what it is. A casual word, that such and such a hill was once a volcano, or that the land was once the bed of a sea, may be sufficient to start a study of the whole subject.

It is with matters such as these that geology deals. And it is all to the good when the investigation begins with some point in local geology that insists on explanation. For this is an out-of-doors subject, and its study must not be divorced from the investigation of the actual phenomena within reach. And the student has to realise that the explanation of the present-day conditions depends on a geological history which claims for itself a length of time which is practically unrealisable. "The first thing you learn," said a well-known professor of geology during an excursion, "is weathering, and it's the last thing you do learn." For the results of its action are so stupendous that they can scarcely be credited.

Our first study, then, is of the agents which produce geological change. It is now held with practical unanimity that the forces which are acting at the present day to modify the existing state of the earth's crust are sufficient to explain all the changes that have taken place in the past. There is no need to invoke the aid of other and more powerful agents, though it is not necessary to maintain that they have always been present in the same degree or proportion throughout the earth's history.

EPIGENE AGENTS

The forces producing geological change are divided into two classes: those that act on the exterior of the earth's crust, and those that are internal. The first are called exterior, subaërial, or epigene; the second interior, subterranean, or hypogene. These classes must now be considered in detail. But it must be understood that neither group by itself would be sufficient; it requires the combination of both to give us the earth as we know it.

With regard to the epigene agents, perhaps the most striking fact is the apparent insignificance of the forces for which are claimed results of such magnitude. The forces whose action we are to consider include wind, rain, frost, rivers, &c. These are incessantly at work, ever rearranging the familiar features of the land, and though a lifetime, or a whole series of lifetimes, may detect little difference, still all things change, and change enormously in the course of geological history.

Wind, though not the most important of these agents, is the most universal. In this country the sand dunes that fringe parts of the east coast are the direct result of the wind's action in blowing inland the sands of the seashore. In other countries the wind has had a much more important effect. The Black Earth region of Russia is said to derive its rich soil from the Scandinavian centre of glaciation. When the glaciation diminished and the glacial silt became dry, the winds bore the fertile soil in a steady drift to this region. Similarly the loess of China, which in parts attains a depth of 2000 feet, has been borne from the dry interior of Asia by the wind. In desert areas like the Sahara the wind is constantly blowing the sand against all obstacles and wearing these away, whether the obstacles be buildings or rocks. In the course of ages the effects produced in this way are very considerable. The sand grains themselves get their angular corners knocked off in the process, and this rounding is not confined to the larger grains, even very small grains are seen under the microscope to be rounded. With water-worn sand this does not take place, as the smaller particles are held in suspension, and only the larger grains suffer from the effect of friction. It is remarkable that several of the sandstones of this country are seen on microscopic examination to consist of particles which are all rounded or sub-angular, showing that they are wind-worn, and possibly giving a clue to the nature of the climate at the period of their formation.

Change of temperature, too, produces considerable effect when continued over a long period. For the different materials of rocks expand and contract in different degrees, and a great range of temperature in the course of

day and night is enough gradually to reduce rocks to fragments. This agent is very active at the present day in certain desert areas. But agents which are negligible in our own country at present are not to be overlooked in geology. For geological history tells us of many changes of climate in Europe, and a factor which is unimportant now may not always have been so.

In considering next one of the most important groups of agencies producing change—the *Aqueous agencies*—the one connected with change of temperature may be taken first. For when water has percolated into cracks in the rocks and there freezes, the expansion which accompanies freezing is sufficient to splinter the hardest rocks. The jagged appearance of many mountain tops is due to this, as is also the "scree" of broken material at the foot of the pinnacle.

The action of **rain** is very important. Continual dropping wears a stone, and geology can supply many evidences of that. Loose particles, soft rock, and in time even the hardest rocks, are all in process of being worn away, swept into streams and rivers, and finally carried out to ocean. And in addition to this, rain has a chemical action. Rain water always contains a certain proportion of carbonic acid gas dissolved in it, which it obtains in its course through the atmosphere, and of which it gains more in passing over the surface of the ground. This gives it the power of dissolving many rocks such as limestones and chalk, and of disintegrating such hard rocks as granite, carrying away a great deal of the substance of the rock in solution, and leaving behind the soft substance known as china-clay, along with certain unacted-on minerals. Then the rain easily removes the china-clay by its mechanical action.

Springs play an important part in dissolving away such rocks as limestones. When they come to the surface they always contain a certain amount of material derived from the ground through which they have passed, and the action of rain water in percolating into the ground often disintegrates rock to a very considerable depth below the surface. Some of the material they bring to the surface is carried down to the sea, but often they deposit part of it when they reach the surface, forming sheets of travertine or of siliceous sinter. Stalactites and stalagmites are due to the same action. The process is as follows: The underground water, charged with carbonic acid gas, dissolves a quantity of calcium carbonate from the limestone rock through which it has passed. When it emerges into the open air of a cave it loses some of its gas, is unable to contain so much carbonate of lime, and therefore deposits some of it on the roof of the cave. The drop then falls and deposits more on the floor of the cave, and this continues till there is an icicle-like formation depending from the roof of the cave and another growing up to meet it. In the course of time these meet and form pillars.

Streams and rivers are most important agents. They transport material which has been broken up by other agents. And they themselves are constantly wearing away their banks and bed. They make use of the fragments they transport like the "arming" of a tool to grind away the rock over which they flow. All the solid material they carry, except the very finest (which is carried in suspension), is itself being smoothed and rounded by constant friction against the bed and sides of the river and being reduced in size. There is also a quantity of material carried in solution. When the river begins to slow down, a process of deposition begins. First of all the larger pebbles are deposited, and then smaller and smaller pebbles, and finally sand and mud, only the very finest particles reaching the sea or river estuary. Probably most people when they think of the matter at all, are of opinion that the rivers they know flow in the valleys just because the valleys happen to be there and water always seeks the lowest level. But in reality this is putting the cart before the horse. For the valleys are there because the rivers and streams, aided by the other epigene agents, have made them. Imagine a plateau with a slope in one direction down which water will flow. The water will soon make a channel for itself, which it will continually deepen. Were there no weathering action going on, the channel of the river would soon be at the bottom of a deep gorge with vertical sides. This is exemplified by the Grand Canon of the Colorado River in North America, where the river has made for itself a gorge more than 300 miles long, and over a mile deep in places. But when frost shatters the rocks, and rain and wind are active, the sides of the valley are being continually benched back, and the river flows at the bottom of a continually widening valley. The character of the landscape will of course depend on the nature of the rock which the river and its tributaries have to wear down. This will be considered later. But it is to be noted that the mountains and hills of our country are merely the high land which still remains when the rivers have done their work with the help of the other exterior agents. That is what is meant when it is said that all the mountains of Britain are mountains of circumdenudation. They are constantly being reduced in height too, for these agents are constantly at work wearing them away.

The **sea** is another aqueous agent which is never at rest in its modifications of the land surface. Its action on the pebbles of the beach is one of constant wear, rounding, smoothing and polishing, and reducing in size. The scour of the tide is rearranging the coast, transporting material from one part, depositing material in

another. There is also the action of the waves on the cliffs that border the shore. Where the rock is softer than its neighbours, caves are worn out. In the case of the hardest cliffs the waves, armed with shingle, undermine the base, and the overhanging portion eventually collapses. Where there are cracks in the rock, air may be imprisoned by the waves and the force of compression makes it almost an explosive charge which helps on the work of disruption.

In modern times the action of **glaciers** is still going on in different parts of the world, and their influence has been carefully studied. Though a glacier has been called a river of ice, and though there is in many ways a correspondence between the results of the two, yet there is an equally important set of differences which make glacial action easily differentiated from river action in its results. On the surface of modern glaciers are to be seen long lines of rock material (moraines) which has fallen from the heights above. These are transported bodily to the end of the glacier, undergoing no process of smoothing down such as rivers would have subjected them to, and undergoing no process of sorting out such as a river exercises when it deposits the material in order of heaviness. The same applies to any material embedded in the mass of the glacier. The only stones that can be altered are those at the bottom, which the glacier uses as a tool for cutting, scratching, and polishing the surface over which it moves. In this process the stones of this bottom moraine are themselves often shattered, but more often simply smoothed, scratched, and polished—usually on one surface only, and on this surface the striations all lie in one direction. Thus at the point where the glacier ends and the glacial river begins, the transported material is all dumped down in confused heaps, stones of all sorts and sizes mingled with earth which may escape being carried off by the river. These form mounds which are either arranged in somewhat parallel lines or have no sort of arrangement at all. It is the existence of such mounds in our own country that forms one of the proofs of the great ice age during which nearly all the country was smothered in ice. Glaciation leaves other evidences of its former existence. The ice in its progress breaks off all projecting points, mountain peaks are rounded off, serrated edges lose their sharpness, and everywhere smooth and flowing lines rule in place of angularity and sharpness. Crags are worn away on the exposed side, while the lee side is protected and may even receive deposits of boulder-clay from the glacier, giving rise to that feature of the landscape which is often seen, known as crag-and-tail. The terminal moraines may be sufficient to dam up a river and form a lake, with the result that in countries that have formerly undergone glaciation lakes are commonly more numerous than elsewhere. Rocks over which the glacier has passed are smoothed and scratched, often giving rise to the appearance which gives them the name of *roches moutonnées*. The striations indicate the line of ice flow, and by looking at the rock, first from the one side and then from the other, the greater smoothness of the one side indicates the direction of flow. Rocks are often also carried far from the parent mass and deposited in a distant district where the rock is entirely different in character. These are called erratics. Many "perched blocks" originate in the same way.

The last important epigene agent is **organic**. A great amount of rock is composed of the remains of living bodies, both animal and vegetable. Decaying plants may sink into the ground, and there in the course of time become mineralised. The skeletons of land animals are often embedded in swampy soil, but this result is trivial compared with the results produced by the plants and animals of the ocean. Coral reefs are being built up by the coral polyp in tropical waters. This animal secretes carbonate of lime from the ocean. This substance is supplied to the sea by the rivers which have carried it down in solution. Another most important animal agent which secretes limestone is the globigerina. The globigerinæ are extremely minute forms of animal life with tiny globular shells. They live on the surface of the ocean, and when they die their shells fall to the bottom. There is a continual rain of these falling and settling on the floor of the ocean. The importance of this action will be understood when it is said that the chalk cliffs of England are composed almost entirely of the remains of similar organisms. This globigerina ooze is not found in the deepest parts of the ocean, for in falling through the water they are subjected far too long to the solvent action of the water, which contains a proportion of carbonic acid gas dissolved in it, and never reach the bottom. Other organisms secrete silica, which is also ultimately derived from the land and carried to the sea in solution. Diatoms are tiny plants whose remains form diatom ooze, and radiolarians are animals which have shells that cannot be dissolved by the water in their falling to the bottom, and therefore form a sufficiently large proportion of the deposits of the abyssal regions of the Pacific to give these the name of Radiolarian ooze.

Action of this kind, seemingly insignificant, is when continued for ages an important factor in the formation of rocks. Any further consideration of this subject will be more appropriate later.

HYPOGENE AGENTS

We come next to the consideration of the *Hypogene Agents*. It will be observed that the epigene agents act as a whole in reducing every-

thing to one common level. Mountains are being gradually reduced in height and the lowest stretches of land are as steadily being raised by deposition until all comes to one "base level of erosion." Even the floor of the ocean is being elevated, however slowly. But obviously the land is far from having reached that stage, and this is due to the internal agencies. The most obvious of these is the *volcano*, which throws out on to the surface quantities of material in the form of large blocks and smaller particles down to fine dust. There are also poured forth streams of molten rock. This molten rock may be forced through the surrounding rocks instead of coming to the surface. The lava which flows over the surface has certain characteristic features. It contains a great deal of steam, which in escaping leaves a cindery or slaggy appearance on the surface of the flow; and often indeed on the under surface also, when the slaggy material has fallen down in front of the flow. The steam bubbles are often seen to be elongated in the direction of the flow. That part of the lava which cools most rapidly forms a volcanic glass.

Earthquakes too are obvious results of internal causes, and often cause alteration in the level of the land. But much more important are the great crustal movements which are going on, supposed to be due to the shrinking of the globe as it cools. There is distinct evidence of both elevation and subsidence having taken place within historic times. This movement has been of the greatest importance, and geology has many results to show that can only have been produced by this means. Along many parts of our coasts raised beaches can be seen at different heights above sea-level, each pointing to a period of elevation. And on the other hand the existence of submerged forests points to subsidence. The story of the rocks proves that there have been many movements of upheaval and subsidence both, each lasting for prolonged periods. As we study the different classes of rocks we shall come to know many of these evidences.

PETROLOGY

Assuming that the agencies at work at the present day are substantially the same as those which have been at work all along, the next thing to be done is to form some idea of the different rocks and get as far as possible an explanation of their composition, structure, and mode of origin.

There are three great groups of rocks: (1) the Aqueous, Sedimentary, or Stratified Rocks; (2) the Igneous Rocks, which are subdivided into Volcanic and Plutonic; and (3) the Metamorphic Rocks. These will in turn require consideration.

It is probable that your own district does not contain examples of all the types, though they may be found at no inconvenient distance. At all events, you ought to make yourself as familiar as possible with the varieties of rock at your own doors, so to speak. You will often be puzzled at the start, but most likely a good many obvious types can be found.

Sedimentary Rocks.—The first of the great classes, the Sedimentary Rocks, are so called because they have been deposited as a sediment in water, either in rivers, or at river mouths, or in lakes, or the open sea, just as sediments are being deposited at the present day. They have been deposited in layers, though the layers alter their character if you trace them out over a distance. These rocks differ from the present-day deposits as a rule by being consolidated, generally through the action of some cementing material such as carbonate of lime, silica, or oxide of iron.

You may be able to inspect some quarry in your neighbourhood that shows evidence of stratification. When you find layer upon layer of rock, possibly differing in structure, you will be able to answer for yourself the question of the condition under which each was deposited. To take some examples. If there is sandstone, then you can say that that particular stratum was once part of a river bed—perhaps a delta, or part of a seashore, or at the bottom of a shallow sea or lake. A *conglomerate*, which is made up of pebbles cemented together, must have originally been a sea beach or a river bed. You may find the conglomerate shading off upwards into finer material. This may mean that it was deposited at a river mouth, but the land gradually subsiding, the coarser pebbles were deposited farther up stream and the velocity of the river became so small as only to carry sand where it once transported pebbles.

If there is a bed of clay or shale you may ask yourself under what conditions such deposits are being made at the present day. They are all made in places where the deposition takes place very slowly, as in the fairly deep water off the shore, or in the deep water of lakes, or in the alluvial plains of rivers. The clay or shale of the quarry must therefore have been once deposited under such conditions.

It is a fairly common thing to find on a slab of sandstone such evidences of the condition of formation as ripple marks, worm casts, the pittings made by rain drops, or even the footprints of some animal. Sometimes in sandstone, and more often in shale, fossils may be found, perhaps the shells of some animals which have died and been slowly buried under the steady deposition. These have played a part in Historical Geology whose importance cannot be overrated.

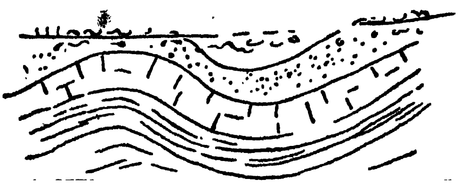
Sandstones and shales are mechanically-formed rocks; they have been formed by the wearing away of older rocks. But there is another group of sedimentary rocks which are

organically-formed. The two most important are limestones and coal, and of the limestones the chief is chalk. A chalk cliff therefore must be imagined as having once been at the bottom of a deep sea of clear water on whose surface the minute organisms of foraminifera like globigerina lived. Coal is formed of the remains of plants which flourished on swampy soil and under tropical conditions. The discovery of coal beds near the South Pole leads one to see how the world's climate has changed.

Chemical Deposition.—As an example of another kind of deposition—chemical deposition—mention may be made of the beds of rock-salt, which must undoubtedly have been the salt of inland seas like the Dead Sea, where there was no outlet for the water and where the climate was hot enough to evaporate the water and allow the salt to crystallise out.

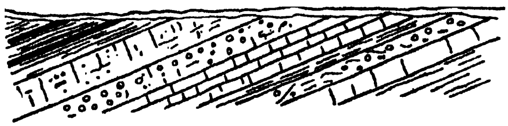
As far as possible the local sedimentary rocks ought to be studied to see how much of the above may be verified, and an attempt made to reconstruct in imagination the conditions of their formation, and to realise the vicissitudes that the land has gone through. You will in all probability be confronted at once with other evidences of such vicissitudes, possibly in the quarry or cliff itself, certainly in a more extended survey.

First of all, it is obvious that these beds when laid down must have been practically horizontal. But very likely you will find that the strata, instead of being horizontal, are inclined. This is the result of earth movement. The earth, cooling and shrinking, wrinkles its crust, and in so doing the strata become bent. Although the earth is a shrinking body, that is not inconsistent with local upheaval over wide areas. For the solid crust has to accommodate itself to a shrinking core, and this implies wrinkling, elevation in one place and subsidence in another. Inclined strata are therefore the rule and horizontal strata the exception. Curved strata may be found within very small limits giving the appearance shown by the sketch. And strata that are apparently



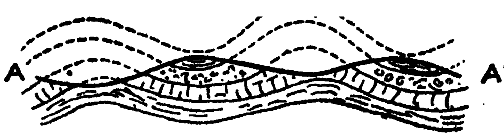
inclined at one definite angle are not so in reality, for on following up a stratum it is found to be bent into curves like the waves of the sea. The crest of these curves are called anticlines and the hollows synclines. The angle at which a stratum at any place is inclined to the horizontal is called the *dip*, and the line along the stratum at right angles to this is the *strike*. Thus if a book is tilted on the table the sloping edge gives the dip and the horizontal edge gives the strike. The place where the stratum comes to the surface is called the *outcrop*.

It is important to notice that though strata are undulating the level of the ground gives no indication of this at all. It is a very common mistake to imagine that undulating ground means undulating strata underneath, or rather that the slope of the strata determines the slope of the ground. If you look at a railway cutting, say, where inclined strata are exposed you will see something like the sketch.



In all probability the strata, after being deposited perhaps at the bottom of the sea or lake, began to be arched up, and slowly rose above the surface. But as soon as that happened denudation would set in and the top of the arch would be gradually planed down. If the movement went on slowly enough, and these earth movements are as a rule extremely slow, the elevation would probably never proceed far above sea-level.

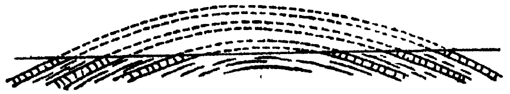
Indeed, so little do slope of strata and slope of the ground correspond that there is a very general tendency for them to be in exactly opposite directions. Synclines are often found to be at the tops of mountains and anticlines in the valleys as in sketch, where AA′ is the actual surface, and the dotted lines represent the amount of land that has been worn away by the agents of denudation.



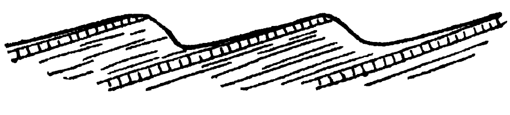
The explanation is that an anticline is essentially a much weaker structure than a syncline, and if weathering has long enough to act it wears away the anticlinal structure much faster than the synclinal. For there is a disposition for many stratified rocks to form joints, and these often divide up a stratum into a series of large blocks. Now, to put it crudely, these blocks have a tendency to tumble away from each other in an anticline and towards each other in a syncline. And the weathering action follows this sort of rule.

In the case of escarpments and dip slopes, slope of ground and of strata do in part coincide.

The origin of this feature of the landscape is this. A series of strata, consisting of alternating hard and soft beds, is deposited at the bottom of the sea. Then elevation begins to take place. As soon as the surface is reached the planing action of the waves begins and the result is as in sketch.



We shall now consider the left-hand side of sketch. When elevation takes the land beyond reach of the waves the differential action of the weathering begins. The original slope of the land surface, considering the mode of upheaval, will probably be to the left, and down this slope the original rivers will run, cutting across hard and soft strata indiscriminately, mayhap forming waterfalls or rapids at the outcrop of the hard strata. But the various epigene agents acting on the rocks at each side of the river will wear away the soft rocks much more quickly than the hard ones. Thus a landscape is produced whose appearance will be as represented in sketch.

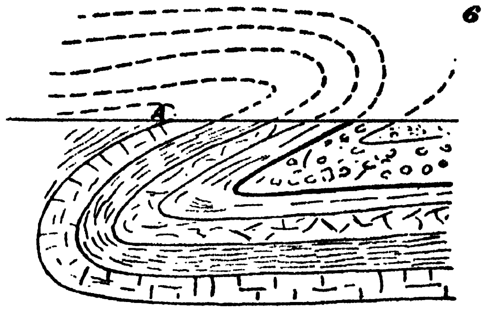


At the summit of each escarpment will be a stratum of hard rock, while in the vale at the foot of it will run a stream, tributary to the original river, which carries off the waste from the escarpment. The slope to the right of the stream in the figure corresponds roughly to a dip slope.

In the case of the youngest mountains of the world there is a sort of general correspondence between surface features and underlying strata. But in all of them weathering action is already fast altering this, and every year brings about a greater disparity.

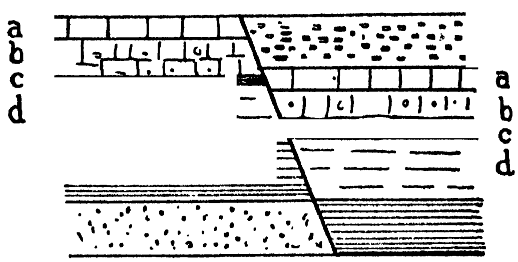
It is obvious that as a general rule the strata to be found at the bottom of a section are the oldest, while those at the top are the youngest. But there are exceptions to this rule. The crustal movements which give rise to curved strata may go still further and produce *overfolds*. If in the diagram representing an overfold the upper portion is supposed to have been removed by denudation, then it is evident that a boring at the point A will pass through the older formations first.

Overfolding has sometimes taken place on a gigantic scale, and only the greatest patience and skill of geologists has enabled them to disentangle the thread of the geological record. The study of the order of succession of the rocks of the earth's crust is a branch of Historical



Geology, one of the most important departments of the subject.

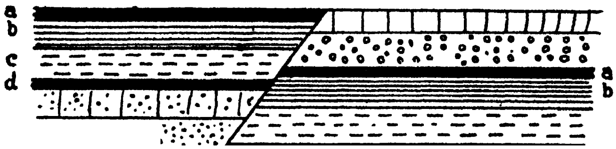
Faults.—Earth movements, responsible for folding of strata, are also responsible for *faults*. Strata have not been able to submit to an unlimited amount of displacement, and the result has been that they have often fractured along certain lines and suffered a relative displacement. A diagram will make this clear. The



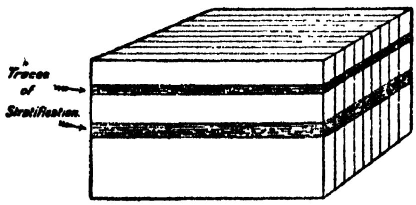
fault may be on a very minute scale, so that a hand specimen will show it; in other cases it may extend for miles in length, and the dislocation may have displaced the strata for thousands of feet. Do not suppose, however, that such enormous faults have produced cliffs miles long and thousands of feet high. Faults have not as a rule been startling phenomena; they have proceeded with almost inconceivable slowness. Rivers which flowed across the fault plane continue to do so during the slow dislocation of the crust and seem to have found no barrier to their progress. And as inequality of level began to be produced, the weathering agents would attack with greater intensity the higher ground to the one side of the fault, and there would be no apparent difference of level. Naturally this will not invariably be the case, and in particular where the weathering action of rain is absent there may be a distinct difference in level.

Faults are of two kinds; the one represented above is a normal fault. Here the strata to the right of the fault seem to have slipped down the

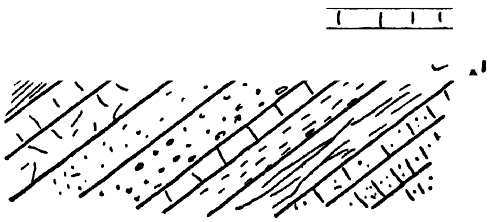
fault plane. In inverted faults the strata seem to have been pushed upwards. In the one case there is a "downthrow," in the other case an "upthrust."



It is not surprising to find that in the course of these earth-movements the strata have often been subjected to enormous pressure. It is this that has turned clay into slate which splits up into thin laminæ at right angles to the pressure, with a cleavage that bears no relation to the original stratification, though generally at right angles to that also. Traces of the original lines of stratification are sometimes found as in sketch. But the formation of slate really belongs to the question of metamorphism.



It has already been said that a section may show many of the vicissitudes that the crust of the earth has undergone, and some of these have been discussed. Still another may be mentioned, that of *unconformity*. A diagram will make this clear.



AA′ represents a line of unconformity. Obviously the strata above this line have not been laid down upon the strata underneath without a break in the succession. After the first set of strata was laid down there has been a period of earth-movement, elevation, and denudation, then a further period of subsidence and deposition. Since then, of course, there has ensued another period of elevation to bring the rock to its present position.

Igneous Rocks.—A conglomerate is easily seen to be a rock made up of pebbles set in a matrix of cementing material; similarly a sandstone consists of particles of sand cemented together. Under the microscope clay is also seen to be composed of very fine particles. These sedimentary rocks have all one point in common, they are formed by the break up of older rocks by all the processes of weathering and denudation. Organically formed rocks too, such as chalk, have built up their hard parts from material in solution in the sea, material which is derived from the rocks of the earth's crust during weathering. But there is another class of rocks which examination shows to be entirely different in structure from these. A piece of granite may be examined as a sample. Inspection shows that this rock is not formed of a number of similar particles cemented together. It is easy to distinguish at least three quite distinct substances. The first to attract attention is white or pink, and on close examination will be found to possess a definite shape. Each of these particles is a crystal, and there will most likely be crystals of different sizes in the specimen. Another crystalline substance will be seen, almost certainly in some cases showing six sides. In appearance it is shiny and is either black or silvery, or both types may be seen in the one specimen. This is mica, and it will be found easy to flake off scales from the six-sided crystals with the point of a knife. The other particles of mica are also six-sided, but happen to be embedded in the mass too much end-on to show this shape. Both the mica and the other substance, called felspar, are set in a matrix which is clear and glassy, sometimes not easy to see without a lens. This is quartz. It presents no definite shape, though in reality its molecular structure is as crystalline as the others. These three substances are called the minerals of the rock granite.

The mode of formation of granite is not open to doubt. In the laboratory crystals can be formed in three ways, by solidifying from one of the three non-solid states, *i.e.* from vapour, solution, or liquid. The laboratory also proves that the slower the process of crystallisation the larger are the individual crystals. It is a common thing for schoolboys to compete with each other to see who can form the largest crystals. Granite, it has long been recognised, is a crystalline rock which was once in a molten condition. The extreme size of its crystals points to extreme slowness in cooling. It is the different rates of cooling, pointing to different conditions of formation, that divides the igneous rocks into plutonic and volcanic. Igneous rocks may be studied from different points of view. Their mode of origin, their rock-structure, their chemical and mineralogical

composition have all to be taken into consideration.

Igneous rocks have all been at one time in a state of fusion. But some are coarsely crystalline; others, while still entirely crystalline, have much smaller crystals, so small perhaps as only to be seen under the microscope; still others have crystals embedded in a non-crystalline or "glassy" base. Some have no crystalline matter at all, or only a rudimentary indication of crystallisation.

It is all a question of conditions of cooling. If a molten rock is cooled quickly there is no time for crystals to form, and a "glass" is the result. At the present day lava forms such a rock. If the lava is a thick sheet there may be found on the surface a slaggy material, a glassy material at the bottom, and in the centre a plentiful supply of small crystals in a glassy base. These conditions are found repeated over and over again in older rocks. The presence of a vesicular structure on the top shows that the lava was originally poured out on the surface of the land. If the lava has been forced from the volcano in amongst the surrounding rocks and not ejected on the surface, then both sides will show glassy structure where the cooling has been rapid, and there will be an increase in crystallisation towards the centre.

Modern lava sheets show evidence of their original fluid state in their flow-structure. The flowing mass forms streaks along the line of flow, and the rudimentary crystals arrange themselves in lines. This structure can be seen both in the hand specimen and in sections for the microscope. The escaping bubbles of steam are often drawn out along the line of flow also. These evidences of lava origin are often seen in ancient rocks. The vesicles formed by the escaping steam are sometimes in ancient rocks filled up with deposits from infiltrating water, giving the rock an amygdaloidal structure, so called from the resemblance of these deposits to almonds.

When igneous rock is found amongst sedimentary rocks it is possible to tell from observations of the above type whether it is of a later age than the rocks above it or is what is called contemporaneous, *i.e.* later than the rocks beneath it and earlier than the rocks above. In this case it has been poured out at the surface, and its age can be told from its position. When the molten rock has been forced along a line of stratification, forming a "sill," there will be no slaggy upper surface and no steam bubbles. In addition, the rock both above and below the sill will show evidence of having been altered and baked by the intrusive rock, and sometimes in following the formation across country the intrusive rock may be found to have broken across from one line of stratification to another. Occasionally the stratified rock above, particularly at anticlines, has been so weak that the intrusive rock has forced it to rise, and has collected in a great mass underneath called a laccolith or laccolite. When denudation has worn away the overlying strata the laccolite is exposed, and some form conspicuous features in the landscape.

Often the molten rock is forced across the strata, forming dykes. They are very commonly vertical, and if the strata across which they have been forced are more easily worn away they stand out as prominent objects. Sometimes they themselves are the more easily weathered, and in that case they form trenches.

Many great masses of igneous rock have cooled deep down under the surface, where the cooling has been a matter of ages perhaps. These necessarily are wholly crystalline, and the crystalline structure is on a large scale. If, after crystallisation has begun, the mass is forced to the surface or near it, the crystals already formed may be found embedded in a glassy base. These wholly crystalline rocks, when exposed by denudation, give us rocks of a granite type.

Volcanic mountains are not very durable structures in a geological sense, and therefore it is not surprising that there are numerous lava-flows in this country whose parent volcano has entirely disappeared. In other cases the lava which welled up in the crater of the volcano and solidified there is all that is left of the volcano. Such volcanic necks, as they are called, are not uncommon in Britain.

When molten rock solidifies it contracts, and it is this contraction that gives rise to the columnar structure so often seen in old lava-flows and sills. The contraction forms cracks which extend at right angles to the plane of cooling. As the strain is uniform the cracks tend to be uniform also, and the shape they assume is the hexagonal for something like the same reason that honeycomb is hexagonal. In this way we have such structures as the Giant's Causeway and Fingal's Cave.

Chemistry of Igneous Rocks.—Having now examined the igneous rocks from the point of view of their origin, they must next be looked at from the point of view of their chemical and mineralogical composition. To do this thoroughly would involve a very considerable incursion into the domain of chemistry, but a short survey of the subject must be given here.

Nearly half of the weight of the earth's crust consists of oxygen, combined of course with other elements. More than half of the remainder of the weight is due to the element silicon. Of the composition of the interior of the globe the geologist can say nothing, but it is probably very different from the crust. The oxygen and silicon combine to form silica, and this makes up more than 60 per cent. of the

weight of the crust. The oxygen also combines with other elements to form the oxides known as alumina, lime, soda, potash, magnesia, oxides of iron, and water.

Chemistry tells us of the important division of many substances into acids and bases. These are often found united together, and this is the case with the crust of the earth. The substances called silicates are combinations of the acid part silica with one or more of the bases alumina, lime, &c. The most important silicates are the felspars; these are silicates of alumina plus one or more of the silicates of potash, soda, or lime. They make up nearly half of the earth's crust.

Now all the rock magmas which give rise to igneous rocks are silicate magmas. On consolidation it is found that sometimes there has been an excess of silica, which has therefore to solidify without combination with any of the bases. This is the free quartz of granite. All igneous rocks are divided, according to the total percentage of silica present, into acid, intermediate, basic, and ultra-basic; and a classification can be made of the igneous rocks on the double basis of chemical composition and degree of crystallisation. Rocks which are intermediate between true volcanic and deep-seated plutonic rocks are often called intrusive, as they are generally found in dykes, sills and the like. It must be remembered that there is every gradation between the different types; the classification is one merely for convenience. A typical rock of each kind is mentioned.

	Acid (Silica, 65 to 80 per cent.)	Intermediate (Silica, 55 to 70 per cent.)	Basic (Silica, 45 to 60 per cent.)
Volcanic	Rhyolite	Trachyte	Basalt
Intrusive	Elvan	Mica-trap	Dolerite
Plutonic	Granite	Diorite	Gabbro

The ultra-basic group is generally divided into four. They contain less than 45 per cent. of silica. The commonest in Britain is Picrite. It is generally intrusive. A good example is on the Island of Inchcolm in the Firth of Forth.

It would be impossible in so short a space to give any idea of the distribution of these rocks in Britain. For this recourse must be had to some of the books recommended at the end of this article.

In passing from acid to ultra-basic rocks there is a transition in colour from light to dark, and there is also an increase in specific gravity from about 2·6 to about 3·6.

Minerals of the Igneous Rocks.—Something must now be said about the minerals of which the rocks are composed. Minerals are differentiated from each other in several ways. Though occasionally two or more different minerals have the same chemical composition, different minerals as a rule have different compositions. Difference in specific gravity is also important, and is of great value in metallurgy. It is also used in testing gems. Walker's balance is a useful instrument in the field for determining the specific gravity. Heavy liquids are also used to determine this, especially by the elegant adaptation of that method known as the diffusion column. A test-tube is half filled with the heavy liquid and water is poured in. It soon forms a column in which the density increases gradually downwards and the position in which the mineral floats gives its specific gravity. Hardness affords another test. A scale of hardness has been formed, every mineral of which can scratch those which precede it and can be scratched by those which come after it. The scale is as follows:

1. Talc.	2. Gypsum.	3. Calcite.
4. Fluorspar.	5. Apatite.	6. Felspar.
7. Quartz.	8. Topaz.	9. Corundum.
	10. Diamond.	

The first two can be scratched with the finger-nail; the next three can be scratched with a knife; felspar also can be scratched with difficulty with a good knife.

The *streak* of a mineral is sometimes distinctive. It is the mark it makes on a surface of unglazed porcelain, and is in reality the colour of its powder.

The action of acids is a common test; in the field it is most usually applied to distinguish carbonates. When hydrochloric acid is applied to a carbonate effervescence takes place, carbonic acid gas being given off. But with some carbonates heat has to be applied. The fusibility of a mineral in the blowpipe flame is another useful test. The magnetic properties of certain ores have also been made use of.

Colour and lustre and other phenomena due to light are important. The most important of these properties, connected with the polarisation of light, require the use of a petrological microscope with its Nicol's prisms, and the explanation would take up much too great a space here. But the examination of thin sections of the rocks under the microscope is of the greatest importance in petrology.

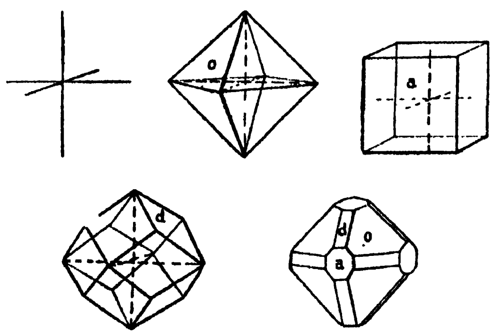
Crystals.—The form of the mineral is also very important. A great many minerals have a crystalline form, and others not crystalline may have some characteristic shape, as wiry, kidney-shaped or reniform, granular, botryoidal (like a bunch of grapes), globular, &c. The study of crystals, or crystallography, is of great importance and interest. When a mineral has been allowed to crystallise from a molten condition without interference from other crystals it assumes a definite shape. This is generally the case, for example, with the felspar and mica of granite, but is not the case with the quartz. The quartz has indeed begun to solidify in crystal form, but the presence of the other constituents which have crystallised before it

has prevented the development of crystal faces. In sections under the microscope, the use of polarised light establishes the crystal structure. Under other conditions, however, it does form complete crystals.

All crystals are found to belong to certain definite systems, and a brief account of those may now be given. They all possess a symmetry, which is greater or less according to the system. At the least they have a centre of symmetry, and every crystal face on the one side of the centre has a corresponding face parallel to it on the other side.

Crystalline Systems.—In all cases the faces can be referred to certain lines or axes within the crystal, round which the faces are grouped. This gives six systems.

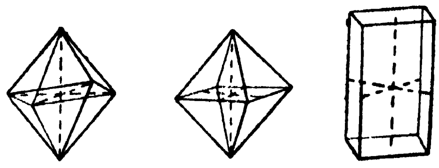
The first is the *Regular* or *Cubic* system, in which the axes are all at right angles to each other and are all equal (see diagram). If now we join the ends of the axes we have an octahedron, the simplest form. If, on the other hand, planes are drawn through the end of each axis parallel to the plane formed by the other two, the result is a cube. Again, the plane faces of the crystal may pass through the ends of two axes and be parallel to the third, giving the rhombic dodecahedron. Combinations of many forms may occur in a crystal, but in every case the faces cut the axes either at unit distance or at a distance which is equal to *m* times unit distance, where *m* is a rational quantity. In the case of the cube one of the axes is cut at unit distance, and the others at distance infinity; *m* has here become infinite. Iron pyrites often crystallises simply as a cube. Galena, one of the ores of lead, generally shows a combination of the three mentioned above.



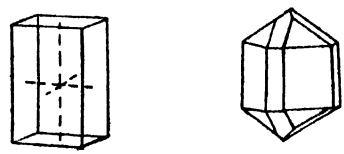
o=octahedron; *a*=cube; *d*=rhombic dodecahedron.

Faces such as the cube faces are called pinacoids; those like the octahedron faces cutting all three axes are called pyramids; those cutting two axes and parallel to a third are called prisms, as in the dodecahedron. When the axis these are parallel to is a lateral axis, they are called domes. Thus the dodecahedron has both prisms and domes.

The next system, the *Tetragonal*, has three axes, again at right angles to each other, two of them equal, but the third is neither equal to the others, nor can it be derived from them by multiplying by any rational number. Different forms are shown. The deutero-pyramid is really a prism form, and the deutero-prism is really a pinacoid. The two prisms are terminated by basal pinacoids. The diagram of tinstone shows prisms and pyramids of both first and second order.

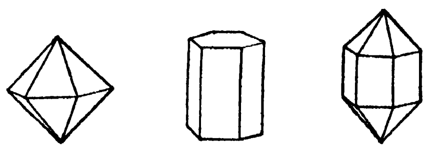


Proto-pyramid. Deutero-pyramid. Proto-prism.

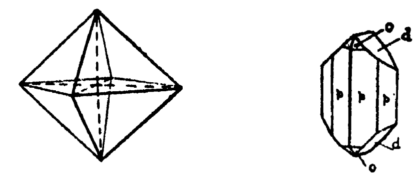


Deutero-prism. Tinstone.

Closely allied to the tetragonal is the *Hexagonal* system, which, instead of two equal axes at right axes to each other has three at angles of 60 degrees. As in the tetragonal system, the vertical axis is in an irrational ratio to the other axes. There are proto- and deutero-pyramids and prisms and other forms where the axes may be cut, not at unit distance but at a distance which is some rational multiple of that distance. Quartz is the commonest mineral crystallising in this system, and one form the crystal may take is shown.



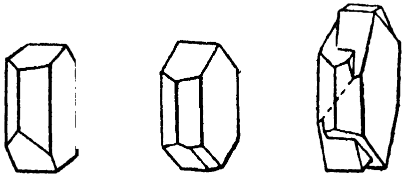
The *Orthorhombic*, or *Rhombic system*, has three axes at right angles to each other and all of different lengths. The faces are pyramids,



o=pyramid. *p*=prism. *d*=dome.

prisms, domes, and pinacoids. The basal plane is a pinacoid in spite of its special name. A crystal of topaz is shown.

The *Monoclinic* system has three axes of unequal length, one of them at right angles to the other two, which are inclined to each other. The faces are pyramids, prisms, and the rest. The felspars are divided into two classes according as they crystallise in this or the following system, the *Triclinic*, which has three axes all unequal and all inclined to one another. A common form of each of the two felspars—monoclinic and triclinic—is shown, and also an example of a twinned monoclinic felspar.



The phenomena of Hemihedrism, Hemimorphism, Pseudomorphism, Twinning, and the like are beyond the scope of this article.

Cleavage is a property of minerals closely connected with crystallisation, though some crystals, such as quartz, have no cleavage.

A list of some of the more important rock-forming minerals may now be given, with the means of identifying them in hand specimens. But it must be remembered that this leaves untouched the vast field of their microscopic properties, seen by examination under the microscope.

Quartz is characteristic of the acid group of igneous rocks and of some of the metamorphic rocks which have yet to be discussed. It is the chief constituent of sandstone, and quartz crystals are often found in veins. It can be recognised by its hardness (=7), its glassy appearance, and the shape of its crystals. But as a rule it has no crystal shape, its outline being determined by the crystals which it encloses. Impurities may produce such coloured varieties as smoky quartz, cairngorm, rose-quartz, &c. There is no cleavage. The *felspars* are found in nearly all igneous rocks, the monoclinic, orthoclase, in the more acid varieties, and the triclinic in the more basic. Both may occur together. They vary in colour from white to pink; they can with difficulty be scratched by a good knife. Their crystal shape is distinct. Orthoclase often shows a line down the centre of one face due to twinning—the two parts of the twin being united along this line. Plagioclase, on the other hand, shows a series of striations due to multiple twinning. The term plagioclase really includes a series of felspars differing in chemical composition and in physical properties, fusibility for example.

There are two kinds of *mica*, white and black. The chief of the white micas is Muscovite, a hydrated silicate of alumina and potash; the chief of the dark micas is Biotite, a hydrated ferro-magnesian and aluminous silicate. They all have an apparently hexagonal symmetry, though belonging to the monoclinic system. They can easily be flaked off with a knife, and the flakes are elastic. The hardness is 2 to 3. They are found in acid rocks, and they are very important in metamorphic rocks.

Hornblende is a silicate of magnesia and lime, sometimes with iron or other constituents. It is monoclinic with a well-marked cleavage, and forms long crystals. It is generally black in the hand specimen, but may be brown or green. Its hardness is 5 to 6, and it is common in acid and intermediate rocks.

Augite has much the same composition as hornblende, has the same colours and hardness, and belongs to the same crystal system, but forms shorter crystals with a much less perfect cleavage. It is found in more basic rocks than hornblende.

Olivine is a silicate of magnesia and iron, crystallising in the rhombic system. Its colour is generally green and its lustre vitreous. Hardness =6. It is characteristic of basic and ultrabasic rocks. In time olivine alters by hydration to serpentine, coloured green, yellow, or red, and with a hardness of 3 to 4.

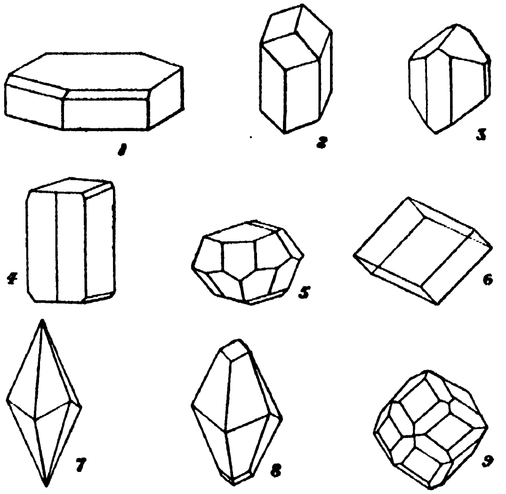
Magnetite, *hæmatite*, and *iron pyrites* are common iron ores. Magnetite and iron pyrites crystallise in the cubic system, the former commonly in octahedra, the latter in cubes. Magnetite is black, hardness about 6, and is distinctly magnetic. Magnetite and hæmatite are oxides, pyrites is a sulphide. Hæmatite often forms nodular masses known as kidney iron ore, or it may form hexagonal crystals of a steel colour and a brilliant lustre. These always have a red streak, whereas magnetite has a black streak. Pyrites has a brassy colour with a brownish streak. Its hardness (6 to 6·5) distinguishes it from gold and from copper pyrites.

Carbonate of lime is found as the basis of limestone rocks; it is also found in crystalline form in veins in the rock, where it has been deposited from solution. It occurs in a great number of forms of the rhombohedral system. This system is a hemihedral variety of the hexagonal system, which means that only half the faces of the hexagonal crystal have been developed. Whatever the shape of the crystal it cleaves very easily into rhombohedra. The crystals are clear or white or stained by the presence of impurities. The hardness is 3, so that it is very easily scratched with a knife. It effervesces readily with hydrochloric acid. Its cleavage, hardness, and the action of hydrochloric acid easily distinguish it from the quartz crystals which also occur in veins.

Garnets are common minerals in metamorphic rocks. They are complicated silicates, crystallising in the cubic system, and with a hardness

of 3·4 to 4·3. They vary much in colour, and are often used as gems.

Some of the common crystal forms shown by several of these minerals are shown.



1. Mica. 2. Hornblende. 3. Augite.
4 Olivine. 5. Hæmatite. 6, 7, 8. Calcite.
9. Garnet.

Metamorphic Rocks.—Having given a short summary of the more common rock-forming minerals, we must now take up the last group of rocks, the *Metamorphic*. The mode of formation of these rocks was long a cause of dispute, but the general principles at least are now established. The rocks are in general more or less crystalline, often coarsely crystalline, but the minerals are arranged in plates or folia, so that the rocks are known as foliated rocks.

The examination of metamorphic rocks goes beyond the foliated rocks, however. There is one feature common to all rocks of this class, as the name indicates: they are all altered rocks. Originally they may have been sedimentary or igneous, but their present state is due to some change, whatever the agent producing the change. In certain cases the history of the change is fairly clear; in others conjecture still plays a considerable part. As has already been said, *slate* is simply clay that has undergone alteration by pressure. This has been established beyond question. Fossils have been found in slate crushed in one direction and elongated at right angles to that direction. The particles themselves show evidence of having been flattened. Often the same stratum can be found in the two conditions of clay in one place and slate in another. And in the laboratory it has been shown that cleavage can be produced in clay by pressure.

Quartzite is another altered sedimentary rock. Examination under the microscope shows that it is a sandstone in which the quartz grains are cemented together by silica crystallising around the old grains. This alteration is due to the agency of infiltrating water containing silica in solution.

Marble is an altered limestone. This is often due to "contact metamorphism." When a molten igneous rock is intruded into sedimentary rocks, the heat given off sets up a profound change in the sediments into which it is intruded. In the case of limestone a gradual change can be traced from ordinary limestone into marble.

Thus at least three methods of producing altered rocks can be mentioned: *pressure*, *water*, and *heat*. Rocks like the three mentioned above, where the original nature of the rock has not been entirely destroyed, are often known simply as altered rocks in distinction to the meta morphic rocks. The foliated rocks are divided into two classes, the gneisses and the schists. In gneiss the rock has a structure like that of granite, but with the minerals arranged in folia. Originally the term was confined to rocks which had the same mineralogical composition as granite, but now it has been widened to include all rocks of a granitoid texture, whether acid, intermediate, or basic. The schists are finer-grained and split up easily into thin lenticular plates. It is now generally recognised that foliated rocks may be produced in different ways. In contact metamorphism, for instance, there may be seen a complete sequence from, say, slate to mica-schist. Regional metamorphism, on the other hand, is largely produced by the crushing and shearing action that results from the shrinkage of the earth's crust. Under this enormous lateral pressure the rock structure and mineral composition assume new forms, and the folia seem to be formed during this re-arrangement. Chemical action may be associated with the pressure. One of the commonest resulting rocks is mica-schist. Garnets are common in metamorphic areas.

The original rock may be either sedimentary or igneous. Often the original minerals remain as "eyes" in the folia, and these minerals may be either crystalline or non-crystalline.

Some foliated rocks may owe their foliated structure to the flow of the igneous rock during cooling. It is probable that a flow while crystals are forming may produce elongated crystals and flow structure in the more micro-crystalline mass enveloping them. This would produce what has been called fluxion metamorphism, though it is doubtful if the term metamorphism ought to be applied at all to such a change. It is an entirely different matter with the rocks that have been metamorphosed by pressure and its accompaniments.

Sometimes an igneous rock in its fluid state is injected along the lines of stratification of some sedimentary rock, in which case the fluid rock not only crystallises itself, but also by its

heat alters completely the character of the rock into which it has been injected. This "leaf by leaf" injection produces injection gneiss or schist.

Enough has been said to show that metamorphism is not a simple process, and a great deal has yet to be done in the way of investigating problems, though in all likelihood the data in many cases will never be sufficient to give a definite answer to the questions raised.

Most of the Highlands of Scotland are an area of regional metamorphism and have contributed largely to our present knowledge of this group of rocks. The north-west highlands formed the subject of a bitter controversy which went the length of parting friends who took opposite sides.

HISTORICAL GEOLOGY

This is the last division of the subject, and is one of great importance. It traces out the succession of the rocks, and examines also the succession of living forms in the history of the globe. As has already been said, the great principle by which the succession is determined is the order of deposition, the older rocks naturally being found below the younger, though in many cases the problem of disentangling the order of succession has been a complicated one. Fossils are of the greatest aid here, and so is the character of the rock. Older rocks are generally more altered; for example, they have been subjected for a much longer time to the action of infiltrating water, and their seams and fissures are therefore filled in with such deposits as carbonate of lime. In general there is a very close agreement as to the order, whatever be the method employed. It is found that the forms of life show a steady development from the earlier forms to the later. It is found that the fossils of the more recent formations bear close relationship to the forms of life now existing; as we go farther back the resemblance becomes less and less apparent. In the earlier fossil-bearing beds there are no fishes, and amphibia, reptiles, mammals, and birds (in the order mentioned) are later still in appearing on the earth. On the other hand, the genera of the earlier rocks have entirely died out, and in the later rocks, while the genera may be the same as those existing now, the species are entirely different until we come to the most recently-formed strata.

A fossil is any relic whatever of the existence of life in geological time. It may be simply a worm-cast or a footprint, but naturally the most plentiful fossils are the hard parts of the animal, as shells, bones, corals, teeth, and the like, which may be preserved unaltered; even trunks of trees and branches may be found unchanged. Sometimes there has taken place a replacement of the original substance by some mineral; this may have taken place particle by particle so as to reproduce with fidelity the original structure in the minutest detail. Again, the original substance may have disappeared and the vacant space filled up subsequently with something else which gives a cast of the original form but does not give any other idea of the structure.

Fossils show the existence of animals and plants which can be divided in the same way as those of the present day. Thus there are nine sub-kingdoms of animals, and these are in turn divided into classes, orders, families, genera, and species. Plants are divided in the same sort of way. But these are really questions of biology, and need not detain us here. For convenience the names of the sub-kingdoms are mentioned.

1. Protozoa, the lowest division. 2. Porifera, *e.g.* sponges. 3. Cœlenterata, having a definite internal cavity. 4. Echinodermata, with thorny skins. 5. Vermes, or worms. 6. Arthropoda, or segmented animals. 7. Molluscoidea, and 8. Mollusca, both having a covering of shell. 9. Vertebrata.

The result of all investigations is to divide up the whole record into certain great groups of rocks with corresponding great life periods. The earliest group is the Archæan, followed by the Primary, Secondary, Tertiary, and Quaternary, and the corresponding life periods are the Eozoic, Palæozic, Mesozoic, Cainozoic, and Anthropozoic. The Mesozoic and Cainozoic are often grouped together under the name Mesozoic, so as to form a period more comparable in importance to the Palæozoic. The great groups are again subdivided into systems and these into formations or series. The complete arrangement is shown in the table.

These will now be taken in detail after some necessary preliminary observations. Below all the other formations, deep down as a rule, stretches a floor of Archæan rock over the whole of Britain. This only appears at the surface where the crust of the earth has been ridged up and suffered denudation. On this floor have been laid in succession the different formations. These are usually continuous across the country, and each stratum rests conformably on the preceding one. Crustal movement has raised these and denudation has sliced them across, so that in walking across England to the south-east one is walking across the exposed edges of the strata in order of deposition. This is not always the case, however. Locally some of the formations may be missing and the strata rest unconformably the one on the other. This implies that while the missing formation was being laid down elsewhere, this particular locality, instead of being subject to deposition, was undergoing denudation; in other words, it formed dry land. When it was again depressed the process of deposition would again resume sway. Parts of the country contain no traces of the later formations, and have

probably been subject to denudation ever since Carboniferous times. The Highlands of Scotland, for instance, seem to have remained above water even during the great Cretaceous depression. But in all cases, though some formations may be missing in places, the order of deposition always remains the same; Carboniferous strata, for example, are never found above Permian.

Conformity between strata points to a gradual process of change from one condition of deposition to another, whereas unconformity points to a break in the conditions, not necessarily sudden, indeed probably very slow, but indicating a great change in the configuration of the land surface of the globe.

The way is now clear for a study of the different formations.

To follow out the order of succession, the student is advised to have before him the Geological Map of the British Isles (Coloured, 2s.), published by the Ordnance Survey.

The Archæan System.—A great deal of obscurity still shrouds this system. There are several types of rock below the Cambrian, and in numerous places the latter does not rest conformably on the pre-Cambrian rocks. A vast extent of Archæan rock has suffered metamorphosis, and its condition before alteration is a matter of conjecture. But there seem to have been both igneous and sedimentary rocks of Archæan age acted on by the agents of metamorphism. There are also several disconnected beds of unmetamorphosed sedimentary deposits. There is evidence that these were deposited in the valley floors of the Archæan land. It seems undoubted that there extended at that time a great land area to the north-west of Britain, the now vanished Atlantis, stretching from the Scandinavian Highlands over the north-western Highlands of Scotland and the Hebrides, and it was the detritus from this land that built up the sedimentary deposits of the Cambrian system. In spite of many

Groups.	Life Periods.	Systems.	Formations.
Quaternary	Anthropozoic	Post-Tertiary	Recent Pleistocene
Tertiary	Cainozoic	Tertiary	Pliocene Miocene Oligocene Eocene
Secondary	Mesozoic	Cretaceous	Chalk and Gault Wealden
		Jurassic	Oolites Lias
		Triassic	Rhætic Keuper Bunter
Primary	Palæozoic	Permian	Magnesian Limestone Permian Sandstone
		Carboniferous	Coal Measures Millstone Grit Carboniferous Limestone
		Devonian	Upper Devonian Middle ,, Lower ,,
		Silurian	Upper Silurian Middle ,, Lower ,,
		Ordovician	Upper Ordovician Middle ,, Lower ,,
		Cambrian	Upper Cambrian Middle ,, Lower ,,
Archæan	Eozoic	Pre-Cambrian	Torridonian, Longmyndian, &c.

vicissitudes this part of Scotland seems to have been the most permanent land of our islands, and is indeed to be reckoned as one of the oldest land features of the world. Off this Atlantis there were probably little islands over part of the area of Britain in Archæan times.

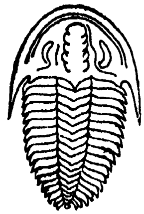
The metamorphic area of the Highlands of Scotland, though the metamorphism is probably mainly of Archæan age, owes at least part of its metamorphism to movements subsequent to Archæan times. This question cannot be gone into more fully here. Of sedimentary rocks of pre-Cambrian age there are three principal exposures in Britain. These are the Torridon Sandstones in the north-west of Scotland, so called from Loch Torridon in that district; the Longmynd strata of grits, shales, sandstones, and conglomerates, in Shropshire; and the slaty and other deposits of the Charnwood Forest of Leicestershire.

This Archæan Group is the era of the earliest life, and hence is called the Eozoic era. But as yet the evidences of life at all are very meagre, at the most only worm burrows and the like—the Eozoon discovered in Canada is not now generally accepted as being a fossil form at all. But with the next system there is plenty of evidence of the existence of eight of the nine great animal sub-kingdoms, and evolution would probably require development of life in the earlier group to account for this.

Palæozoic System.—A great many of the difficulties of the geologist disappear with the next great group—the Palæozoic, or era of ancient life. This group, owing to its marked division into two, is generally divided into *Protozoic* and *Deutozoic*. The strata of the Protozoic rocks are all marine, and their fossils are marine also; those of the Deutozoic have been laid down largely in lakes and estuaries, and their fossils contain many examples of fresh-water animals and land plants. There is also a great difference in the general types of rocks laid down in the two divisions.

The **Protozoic** is divided into three systems, the Cambrian, Ordovician, and Silurian, the *Cambrian* being the lowest. As they were deposited next in time to the Archæan, they are only to be found exposed next to these in space. Thus they are found in a strip bordering the Torridonian, on which they rest unconformably; they are also found next the Longmynd strata. The Cambrian, however, is missing in Charnwood. The three systems of Protozoic rocks are most fully developed in Wales, and this explains the names given to them, the Ordovices and Silures being ancient tribes of Wales. In Wales the Cambrian rocks rest on Archæan igneous and schistose rocks. They are also found in eastern Ireland. They were all laid down in the sea, and the character of the rocks indicates that the sea, shallow at first, became deeper for some time, and then shallowed again. A very great thickness of rock has been laid down, in many cases reaching thousands of feet.

The great characteristic fossils of Cambrian age are the Trilobites, belonging to the class of Crustacea. They get their name from their three-lobed structure. They reached their maximum development in Silurian times, and a few genera lingered on into Carboniferous times when they became extinct. The Cambrian system is divided into three according to the characteristic genus of Trilobite that flourished, the Olenellus, the Paradoxides, and the Olenus marking off the Lower, Middle, and Upper Cambrian. Other forms of life also occur, but there is no real evidence of vertebrata. Mollusca or shell-fish are common, showing representatives of the three great classes, Gasteropoda, Cephalopoda, and Lamellibranchiata. Brachiopoda, belonging to the Molluscoidea, Echinodermata such as star-fish and crinoidea, and other forms of invertebrate life are also found.


Olenellus, Lower Cambrian.

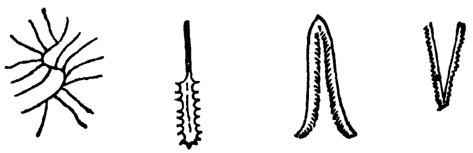
The *Ordovician* rocks rest conformably on the Cambrian. They are very varied in character. Some are shales which have been deposited in deep water; sandstones are found, pointing to deposition nearer the coast of the then land surface; there are conglomerates from old beaches or river mouths. Other deep-water deposits are the limestones, and there are beds containing abundant Radiolaria. It is to be noticed that the thickness of the strata is in proportion to the nearness to the land, and in this way some idea can be formed of the arrangement of land and water in Ordovician times. Most of Britain was still under water, but the Highlands of Scotland formed part of a continent stretching to the north-west. The sea deepened rapidly off the coast, so that the site of the Southern Uplands of Scotland was deep sea. Then to the south it shallowed rapidly again until more land appeared in the English Lake District. Other islands appeared in Wales, Longmynd, and Charnwood.

This period was one of great volcanic activity, and many of the islands were volcanic. Apparently submarine volcanoes were formed, which in several cases rose above the level of the sea. These would be very readily worn down. But great outpourings of lava and volcanic ash, and great igneous intrusions, took place. It is to these that we owe the scenic magnificence of the Lake District and the Snowdon area, since these rocks are more resistant than the ordinary sedimentary deposits. But one must be careful not to imagine that the mountains of these districts are the original volcanoes.

The Ordovician system is found in North and South-west Wales, in Shropshire and East Wales; there is a small exposure in Cornwall, where the rocks contain radiolaria and were therefore a deep-sea deposit; there are no extensive deposits exposed in Ireland. The deposits in Scotland show very clearly the conditions of formation; there is a shallow water condition at Girvan, and a deep-water condition at Moffat.

The most characteristic fossils of the Ordovician are the Graptolites, so called, as some say, because they resemble pencil markings on the shale, according to others because they resemble a quill pen. The two ideas, at any rate, give a very good notion of the appearance of the fossil. The different species have often a limited range in time, and that fact has made them useful in fixing the position of certain strata. It is no uncommon thing to find a slab of shale containing on the one side numerous graptolites of one species and numerous individuals of an entirely distinct species on the other. This of course points to extremely slow rate of deposition, and therefore to distance from the land.

All the sub-kingdoms of the Invertebrata are represented in this system.



Graptolites.

It was somewhere about Ordovician and Silurian times that the faults of Glenmore and the Scottish Rift took place.

The *Silurian system*, which was laid down next the Ordovician, was a period of quiescence; the volcanic activity of the earlier period had ceased, and there are only gentle oscillations of level. In many cases there is an unconformity between the Ordovician and Silurian, showing that the Ordovician had been a land surface and had suffered denudation before again sinking below sea-level and undergoing a period of deposition. Certain of the islands formed during the elevation did not sink below sea-level at all, and the cliffs worn out by the sea are still visible, in Shropshire for instance.

Silurian rocks stretch across the Southern Uplands of Scotland and into Ireland. The Ordovician system dips underneath it. In places such as near Moffat denudation has been carried so far that the Silurian rocks have been cut through and the Ordovician are exposed beneath them. The rocks of the Uplands are shales, and almost the only fossils are graptolites. In the Shropshire area, which is continued into Wales, limestones as well as shales are found, and there are abundant fossils. Brachiopods are one of the most characteristic. Silurian rocks are also found next the Ordovician of the Lake District. In this period graptolites died out entirely, and in this period also the first undisputed evidence of fishes and of land plants is obtained. Abundant remains of fishes are found in a "bone bed" of only a few inches in thickness, but extending over a wide area.

As the beds of this system are followed out over the country they are found to vary greatly in thickness, but the general thickness of the strata amounts to many thousands of feet.

Broadly speaking, the land surface during the whole of the Protozoic times lay to the north-west, from Scandinavia across the Scottish Highlands. The whole of Europe was under water and receiving deposition of Protozoic material. While the strata next the old land surface have been much contorted by earth movement, those of the east of Europe have remained on the whole comparatively undisturbed.

Deutozoic Rocks.—The *Devonian* and *Old Red Sandstone system* is the first of the three systems into which the Deutozoic period is divided. If we consider the sequence of conditions during the Ordovician, Silurian, and Old Red Sandstone times, we find something like the following. The Ordovician strata ended in many cases by being raised above sea-level, and therefore exposed to the agents of denudation. Then came a period of submergence, and on the eroded Ordovician rocks the Silurian strata were deposited. This process of subsidence continued during a considerable part of Silurian times, but before the end of that period a process of elevation began which continued, with oscillations, through the Lower Old Red Sandstone period till the strata were again exposed to weathering. Once more a partial process of subsidence followed, and the Upper Old Red Sandstone was deposited unconformably on the Lower strata. There is no break between the Silurian and the Lower, nor between the Upper Old Red Sandstone and the Carboniferous.

The elevation which closed Silurian times was sufficient to change the geographical conditions in the most radical way. An island-studded sea which washed the shores of a continent to the north-west now gave place to a continental area which included most of Britain and the surrounding seas. In this area were several large fresh-water lakes, and in these lakes settled the detritus carried down by the rivers just as is happening in the lakes of the present day. There must have been a movement of subsidence during the deposition, for in some parts the depth of deposited material reaches 20,000 feet in the Lower only. The rocks are stained red by oxide of iron. Near the margins of the lakes the deposits became coarser, and the old lake shores have thus been traced out. The lakes

have been named according to their position. In the north is Lake Orcadie, which extended from the Shetland Islands to the southern shores of the Moray Firth, and included in its basin the western shores of the Firth and the Orkney Islands. Lake Caledonia stretched across the Midland valley of Scotland, and continued into Ireland. The Welsh Lake occupied a large part of South Wales, and Lake Munster the southern part of Ireland. Other smaller lakes were Lake Lorne and Lake Cheviot.

Though most of Britain was part of a continent, the shore line of this period was not so far south as Land's End. At this time the continental area extended over the north and north-west of Europe, while the ocean occupied apparently the whole of central and eastern Europe. Thus while the Old Red Sandstone was being deposited in the lakes, Devonian strata with marine fossils were being deposited off the shores of the continent, that is, in Cornwall and Devon, and right across Europe. Hence this period shows both Devonian or marine types of deposit, and Old Red Sandstone or fresh-water types. The latter is only a local condition coincident in time with the great marine conditions elsewhere.

The characteristic fossil of the Old Red Sandstone is its fishes, so much so that this period is often known as the Age of Fishes. Many of these were of a very remarkable kind, being protected by an armour of bony scales. None of them had a skeleton developed as in modern fishes.

In this period there was a great amount of volcanic activity in Central Scotland, and enormous quantities of lava and tuff were ejected. It is to the resistant quality of the volcanic rocks that we owe the hill ranges of Central Scotland, such as the Sidlaws and the Ochils, and also the Cheviots, where the original volcanic vent is represented by a plug of granite.

Next in time to the Devonian comes the *Carboniferous system*, so called because it includes in its deposits the coal measures of the country. These coal measures point to a time when an extraordinary development of vegetation took place which may be compared with the dense tropical jungles of the present day. On a swampy soil, with favouring climatic conditions, plants belonging to the Cryptogamia grew to an enormous height compared to that of their nearest representatives of the present day. While the vegetation flourished and died the land was slowly sinking and further growth took place on the top of the dead vegetable matter below. This lasted for a very long period, and extended over nearly the whole of Britain. The too rapid subsidence of the land would sometimes put a temporary stop to the deposition of the vegetation, and other deposits would take their place. Naturally, while some parts were under water others would still continue their vegetation, so that the coal seams of one part of the country are contemporaneous with other strata in another part. This geological period has contributed more than any other to the present prosperity of the country.

But the Carboniferous system includes more than the deposition of the coal measures. Before the deposition of the coal there was a Lower Carboniferous series, often called the Carboniferous Limestone series. This was deposited under marine conditions and is crowded with corals and encrinites. It is developed most typically in Derbyshire and the surrounding land, where it has the name of mountain limestone. Here there was clear and open sea; but as the strata are followed north there is a change in the nature of the deposit such as is produced nearer land, *i.e.* sandstones and shales and the like begin to appear. The Highlands of Scotland seem to have been land, as also were the Southern Uplands, while between the two was shallow water where sandstones, &c. were deposited, and where the conditions sometimes favoured the growth of the plants of the coal measures. To the south of Derbyshire, too, there was a strip of land across England, followed by deep sea still farther south.

In the course of time the area on which was deposited the limestone began to receive deposits derived from the denudation of the land, and this gives the millstone grit, a coarse sandstone whose name indicates its usefulness. Then the deposition of the coal measures began.

There was a considerable amount of volcanic activity during the Carboniferous Limestone period, especially in the Midland valley of Scotland, and the sheets of volcanic material give rise to Arthur's Seat, the Campsie Fells, and other prominent features of the landscape. Salisbury Crags are the result of an igneous intrusion.

At the end of the Carboniferous period there was an important set of earth movements at right angles to each other, which wrinkled the crust into folds crossing at right angles. The result was that the hill ranges formed by these folds at once came under the influence of aerial denudation, and the whole of their coal measures were worn away. The material thus worn away was deposited in the basin-shaped hollows formed by the intercrossing folds, and in this way protected the coal beds in these hollows. This accounted for the position of the coal beds of Britain. In Ireland the only wrinkling was in Munster, and the rest of the country was left comparatively level and exposed, with the result that practically all the coal measures of Ireland have been denuded away, and most of the surface of that island consists of Carboniferous limestone.

Permian System.—Next to the Carboniferous system is a set of rocks that used to be called the *New Red Sandstone* to distinguish it from the Old Red Sandstone; and as a field term the name is sometimes used yet. But now geologists divide these rocks into two divisions, the lower called the Permian, and the upper called the Triassic. Perm in Russia gives its name to the former, the latter is so called because in Germany, where the system is most complete, there is a division of the strata into three groups. This separation of the New Red Sandstone into two is a very important one. The fossils of the Permian are more closely related to those that went before; those of the Trias have affinities with the later; the Permian life was of the more ancient or Palæozoic type, the Triassic, though still far removed from the life that now is, was of the intermediate or Mesozoic type. There is, as a rule, a distinct unconformity between the two.

But as regards conditions of deposit, there was a very considerable similarity between the two. Indeed, this was on the whole a period of quiescence; there was no great upheaval, and no great depression; there was a certain amount of volcanic action, but conditions were generally uniform. A considerable amount of movement took place in later Carboniferous times, and this continued into the earlier Permian, but after that the movements were slight. A large part of Britain was dry land, and therefore shows no Permian deposits. Instead of this it was undergoing steady denudation, with the result that in the Permian strata there are very commonly found pebbles which contain fossils from the Carboniferous strata that have been denuded. Fossils of Permian age are relatively rare. The strata consist of breccias (*i.e.* rocks resembling conglomerates, with this difference, that the fragments, instead of being rounded pebbles, are angular), red sandstones, magnesian limestones, marls, and shales. Evidently these deposits were laid down in a large inland lake or lakes of salt water like the Caspian or the Dead Sea. Such conditions are, of course, adverse to the existence of life. As the water dried up by evaporation, the salts in solution were deposited at the bottom, and this gives the magnesian limestone, formed of the carbonates of lime and magnesia.

The Permian system borders the Carboniferous on each side of the Pennines, and round the southern end of that range, and from there extends to Devonshire. In Scotland Permian rocks are found extending up the valleys that already existed in the Silurian rocks of the Southern Uplands, as Nithsdale and Annandale. The rest of Scotland was evidently above sea level. In Ireland there are deposits near Belfast in Tyrone and Armagh.

The plants of Permian time are still like those of the Carboniferous; the fossils of the animal kingdom include lamellibranchs, brachiopods, &c., among the Invertebrata, and of the Vertebrata there are fishes, amphibia, and, for the first time in geological history, reptiles.

The great result of volcanic action was the upthrust of the granite boss of Dartmoor. Lava flows are also found in Southern Scotland.

Mesozoic Period.—The general conditions of deposition of the *Triassic system* have been indicated. Of the three horizons of the Trias which are found in Germany, only two are to be found in Britain, corresponding to the first and third of the continental deposits; these are called the *Bunter* and *Keuper* respectively. There is usually an unconformity between the Permian and Triassic systems, but no great interval of time elapsed between the deposits. The inland salt lakes were the important geographical feature, and as before, these conditions are unfavourable to life and therefore to fossils. It was during the evaporation of the salt water that the crystallisation of rock-salt took place, to which Cheshire and Worcestershire owe their rock-salt and brine springs. A good deal of deposition seems to have been done on the alluvial plains, and coarse pebbly deposits are found which shade off into finer and finer sediments, as one finds in the case of rivers nowadays. That for a long time desert conditions prevailed seems certain, and the rounded character of even the finest grains of the sandstone of this time affords one proof of this.

By the time the Trias is reached, the old types of life have died away or are on the way to extinction, and more advanced types begin to flourish. Graptolites and Trilobites have entirely disappeared, and in the orders which survived, the forms show a departure from the ancient types and an approximation to the existing types. In the case of plants, the flora of Carboniferous times dwindled away, to be replaced by higher types.

The dominant type till the end of Silurian times was the Invertebrate; from then till the end of the Permian the type was the Class Pisces or Fishes. With Triassic times the Reptilia become the dominant type, and so continue till the end of the Mesozoic. Though the fossil remains of Triassic times are scanty in Britain, they are not so elsewhere. The reptiles have left many footprints in the sandstone of Cheshire and of Dumfriesshire. This, along with worm tracks, rain marks, sun cracks, indicates the shallow-water conditions of the time. But very few other traces of the reptiles have been left in Britain, though the foreign deposits have examples of Ichthyosaurus, Plesiosaurus, Deinosaurus, and many others.

In Britain the Trias stretches practically from shore to shore diagonally across England from the mouth of the Tees, and also sweeps round the southern end of the Pennines north to Morecambe Bay. A small but important de-

posit occurs at Elgin, and other patches are found elsewhere both in Britain and Ireland. In Ireland Triassic deposits have been fairly large in the north-west, but more recent deposits hide them to a great extent. Indeed the beginner can hardly remind himself too often that geological maps only represent the outcrops of strata which may be continuous for hundreds of miles under the surface.

Jurassic Rocks.—Along with the Trias are often grouped the next series, the Rhætic, though some group them with the Jurassic. They are so called after the Rhætian Alps, where they attain a great development. In England they are generally contiguous with the Trias, and are of interest for two reasons. In the first place, they indicate the beginning of a period of subsidence, for many of their fossils indicate that the sea had begun to invade the land-locked lakes, and in the second place, they contain a " bone bed " which, besides containing fossil remains of reptiles and fishes, contains also the remains of the first known mammal, the Microlestes.

The movement of subsidence which began when the Rhætic beds were deposited continued, though not without some oscillations, during the Jurassic period, and the area submerged, especially during the Upper Jurassic times, was of very great extent. Marine conditions prevailed over Central and Eastern Europe, while to the north and west stretched a great land area. An arm of the sea penetrated into the land, covering most of Southern and Central England, skirting the Pennines on both sides and on the west side passing northward over the Irish Sea and along the Inner Hebrides, finally branching off through Glenmore to the east of Scotland. The Jura mountains are formed of strata deposited during this time, hence the name Jurassic.

As a whole, the deposits in Britain indicate a shallow-water condition, but with variety from place to place and from time to time. Typically there seems to have been a shallowing to the north, as indicated by the nature of the deposits, and at times in the north the conditions allowed of the deposit of coal seams. The sea was often clear enough to allow the growth of coral; then, again, shales are deposited, and sandstones nearer the land.

The Jurassic system is divided into two, the Lias and the Oolite; the former generally thin beds of limestone and shale. The Oolites contain thick beds of limestone which are composed of particles resembling the roe of a fish, each particle being a remarkable crystal of calcite round some foreign substance. The Oolites derive their name from this (oolite = roe-stones). There are other rocks in this division, including sandstones, clays, and coral beds.

The fossils of the Jurassic are very numerous and show a great variety of forms of life, Ammonites, whose shells form a plane spiral, are abundant practically all through the period, and are of importance in fixing the position of the zones. They were free floating Cephalopods. The Mollusca are also important. Among Vertebrata the reptiles are dominant; some of these attained enormous size. There were land reptiles—Dinosaurs, sea reptiles—*e.g.* Ichthyosaurs, and reptiles provided with wings, like the Pterodactyl. The first remains of birds are found in these formations.

Jurassic formations extend continuously across England from the English Channel to Yorkshire, and are also found in patches elsewhere in this country. A great series of Jurassic escarpments goes across country from Gloucestershire to Yorkshire.

Towards the end of the Jurassic period, elevation began to set in again, but the earth movements were unaccompanied by volcanic action; there was little crumpling or folding, and the elevation was probably not very great. But the end of the Jurassic period gives fresh-water deposits—the Purbeck beds.

The *Cretaceous system*, following on the Purbeck Beds, begins by continuing the freshwater conditions indicated by these, and the Purbeck clays are succeeded by the sandstones of the Lower Wealden or Hastings Sand formation, which indicates an original deltaic condition. Oscillations of level give clays interbedded with the sand. The tendency, however, began to be one of subsidence. In Northern England marine deposits began to be laid down, while in the south the important Weald Lake or more or less land-locked estuary was formed, occasionally showing marine deposits which at times give way to fresh-water deposits. This gives the Weald Clay, extending over the south-eastern part of England, and the contiguous parts of France and Germany.

Then a further depression took place, and the sea began to creep northward from the Weald, and southward from the north of England, till the intervening land barrier was submerged, and over the area sand was deposited. Thus in the south the Greensand is deposited conformably on the Weald Clay, and in the north on the equivalent marine clays and sands, whereas in between these the Greensand rests unconformably on older strata. With this deposition ends the Lower Cretaceous.

The Upper Cretaceous is ushered in by the Gault, a clay containing marine fossils. Then comes the Upper Greensand, closely resembling the Lower. This is succeeded by the chalk formations. At this time the depression had become much more serious. Almost the whole of Britain was submerged and the whole of Central Europe. Still the land persisted to the north and north-west of the continent. The

sea was moderately deep and clear, in most parts far enough from land to receive none of the material denuded from the land. On the bottom of the sea there gradually accumulated the tiny shells of foraminifera, along with the siliceous spicules of sponges—which formed the nucleus for the formation of those siliceous nodules called flint which are found in the chalk.

The depression was very long-continued, long enough to allow of the depositions of these foraminiferal shells till the accumulation reached a thickness of about 2000 feet. This movement eventually gave way to a period of elevation; a land surface was once more formed over most of Britain, and denudation once more set in, carving out new surface features and wearing away enormous masses of the strata laid down in preceding times.

The Cretaceous system is most typically developed in that part of England south-east of a line from the Wash to Portland Bill. It is also found elsewhere in England, and in Ireland and Western Scotland. Of the fossils, foraminifera and sponge spicules have already been mentioned. Fossils are very numerous. Ammonites die out. Belemnites, which also die out, are characteristic of the Lower Cretaceous. Inoceramus is one of the most characteristic Lamellibranchs. Echinoderms are common. Fishes are numerous, including the earliest specimen of fish with a complete internal bony skeleton. Reptiles of great size lived in Lower Cretaceous times; a number of these became extinct before the end of this period.

The Cretaceous system marks the end of the Mesozoic period.

Cainozoic or Tertiary Rocks.—At the close of the denudation following the deposition of the Cretaceous, a further subsidence took place and the Tertiary formations were deposited, resting unconformably on the chalk, though the unconformity is not very pronounced. Before considering the Tertiary strata, mention may be made of the movement which elevated them. It was a movement that was warped by pressure, so that the strata of Tertiary age and those underlying them were folded into two synclines and two anticlines. Subsequent denudation has cut through the Tertiary strata and exposed the different rocks of the Cretaceous down to the Jurassic. Of course, the anticlines were denuded most, and from these the Tertiary beds have been removed; though they still remain in the two synclines. The terms London Basin and Hampshire Basin are only applicable to the lie of the strata, not to the lie of the surface. It is the more resistant chalk that has formed the north and south Downs.

In Britain the Tertiary formations occupy the two basins mentioned. They are of marine or deltaic origin. During this time there is a great advance in the development of life, and a steadily greater approximation to the life of to-day. The formations are divided to indicate the amount of divergence from the existing life. The oldest is called the *Eocene*, when the dawn of recent life began. The others in order are the *Oligocene* (*oligos*, few; *kainos*, recent), with a few present-day species; *Miocene* (*meion*, less) with less existing than extinct species; *Pliocene* (*pleion*, more) with more existing than extinct species.

Of these the Miocene is absent from Britain altogether; the Eocene is found in the London and Hampshire basins; the Oligocene is found only in the Hampshire basin; the Pliocene is found in neither, but in the eastern counties of Norfolk, Suffolk, and Essex.

The fossils indicate that the climate was for a considerable period tropical or sub-tropical; later it became temperate, and in the end approached the Arctic in character.

This has been called the age of mammals, for they attained a much greater size than the mammals now. The evolution of the present mammals from those of Tertiary times forms a most interesting study; Huxley, for instance, traces the gradual evolution of the horse from its ancestors.

Tertiary times were times of great volcanic activity, both in Britain and in Europe. In Scotland and Ireland great sheets of lava (basalt) were poured out, forming the major portion of Skye, Mull, Rum, Eigg, Antrim, &c. In Eigg the lava flowed down a river bed, which can still be seen appearing from under it. The interesting point is that the river flowed from the west or north-west, showing that the ancient land surface to the north-west of Europe was still in existence in older Tertiary times.

On the Continent there was great volcanic activity first on the northern border, and later on the southern border of the Alps. It was in Tertiary times that the Alps received their greatest upheaval, accompanied by great crushing, folding, contorting, and faulting of strata.

Quaternary Rocks.—Following the Tertiary comes the Quaternary Group. This name is not in universal use; after all, it is only in its infancy. The earlier part is called the *Pleistocene* (*pleistos*, most), the later is called *Recent*. The earlier deposits are the material deposited during the *Great Ice Age*. Underlying the soil is a mantle of unconsolidated material which covers the older formations over a very great part of Britain and Northern and Central Europe. The covering is often hundreds of feet thick. It is entirely absent south of the Thames. It is composed of more or less compact clay, sand, gravel, and larger stones, with no stratification as a rule, and no arrangement of the materials. Nor is there as a rule any evidence of rounding of the stones such as river action would produce. This deposit is the effect of glacial action, and

as this has been described already, little more need be said here. The ice extended over Scandinavia, in which the glaciers originated, the north of Russia and Germany, the Netherlands, and all of Britain down to the line mentioned. The Baltic and the North Sea were both under the sheet of ice. From the Highlands of Scotland other glaciers flowed, to be met and deflected by the greater mass of ice from the north-east. Glaciation was equally great in North America.

There have been several ice ages, and between the deposits of boulder clay due to each come other deposits which indicate a more genial climate, as the plants of temperate climates flourished.

The causes of the ice age are still undiscovered. Different explanations have been brought forward. A different arrangement of the land surfaces might alter the ocean currents, and the flow of water from the Arctic Ocean might cause the Arctic conditions of climate to which the ice age is due. There might have been a change in position of the poles. There might have been an absence of the carbonic acid gas in the atmosphere, which, though minute in quantity, has a great deal to do with preventing radiation of heat away from the earth. There might have been an astronomical cause. The orbit of the earth round the sun may once have been more elliptical, and when the precession of the equinoxes brought round the time when the northern winter occurred at the point of the earth's greatest distance from the sun, the cold might have caused the arctic conditions. In short, the whole problem is still unsolved.

Following the Glacial epoch are the formations which give undisputed evidence of the existence of man. There seems no doubt that man existed during the later glacial period. Since that time there has been a gradual development in the life of man, and deposits have been found which show it. In caves occupied by man their weapons and other traces have been found covered up by layers of stalagmite, and in the bottom layers the weapons are ruder than in the upper ones. River terraces also contain remains of man. The higher river terraces are obviously older than the lower, and in the higher are found the evidence of Palæolithic man. The traces of Neolithic man are found in the lower terraces.

The *Recent* marine deposits are still under the sea; the other geological processes are the formation of peat bogs, the extension of deltas, the filling up of lakes, and the like. There has been some slight elevation and subsidence in Recent times, as is shown by the raised beaches and the submerged forests and in other similar ways.

At the end of our account of Historical Geology one cannot but be impressed by the constant iteration of the words "elevation" and "subsidence," "denudation" and "deposition," and the oft-quoted words of Tennyson come naturally to one's lips:

> "There rolls the deep where grew the tree.
> O earth, what changes hast thou seen!
> There where the long street roars hath been
> The stillness of the central sea.
>
> The hills are shadows, and they flow
> From form to form, and nothing stands;
> They melt like mist, the solid lands,
> Like clouds they shape themselves and go."

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COURSE OF READING

THE following list of books helpful to the student may be arranged in three groups, the first consisting of:

(*A*) BOOKS ON GEOLOGY AS A WHOLE. Textbooks on Geology are so numerous that, even if we exclude those not published in Britain, selection is far from easy. Those mentioned below are arranged, so far as may be, in progressive order: W. W. Watts, *Geology for Beginners* (1898);[1] Lapworth, C., *Intermediate Text-Book of Geology* (1899); Marr, J. E., *Principles of Stratigraphical Geology* (1898); Geikie, J., *Outlines of Geology* (1903); Geikie, A., *Class Book of Geology* (1890); Jukes-Browne, A. J., *Student's Handbook, Physical* (1892), *Stratigraphical* (1912); Lyell, C., *The Student's Lyell*, edited by J. W. Judd (1911); Lake, P., and Rastall, R. H., *A Text-Book of Geology* (1910); Geikie, A., *Text-Book of Geology* (1903).

The last-named book is a large one in two volumes, giving much information about foreign geology, with many valuable references to other books and to separate papers. But it, with two or three at the end of the list, requires students to have mastered thoroughly the more elementary parts of geology.

(*B*) BOOKS ON SPECIAL SUBJECTS.—These will hardly be needed till the student has read the earlier books on the former list, because such subjects are noticed, and sometimes rather fully, in any work, even if it be short, on general Geology. They may be roughly classified under the following heads:

(1) **Petrology**, or the knowledge of rocks. For this subject some knowledge of mineralogy is indispensable, but the above-named textbooks, as a rule, include all that is absolutely

1 The dates in these lists are from the volumes in the library of the Sedgwick Museum, Cambridge, and in most, if not in all cases, indicate the latest editions.

necessary,[1] and the more advanced usually give as much information on Petrology as the ordinary student requires. Those, however, who desire to make a special study of this subject should consult the following books: Harker, A., *Petrology for Students* (1908); Hatch, F. H., *Petrology*, Vol. I, Igneous Rocks (1914); Hatch, F. H., and Rastall, R. H., Vol. II, Sedimentary (1913).

Very advanced students will find *The Natural History of Igneous Rocks* (1909), also by Mr. Harker, a most valuable book; but its nature makes it too difficult for any but them.

(2) **Physical Geology.** (a) *Constitution and Age of the Earth*, a very difficult subject. The student, if not deterred from it, may be referred to two essays in Sollas, W. J., *The Age of the Earth* (N.D.), and to Joly, J., *Radioactivity and Geology* (1909).

(b) *Earthquakes*.—Also a difficult and painfully interesting subject, which is well discussed in Milne, J., *Seismology* (1898), and Dutton, C. E., *Earthquakes* (1904). Much interesting information about English earthquakes is given in Meldola, R., and White, W., *The East Anglian Earthquake of* 1884 (1885), and Davison, C., *Hereford Earthquake* 1896 (1899).

(c) *Volcanoes*.—Judd, J. W., *Volcanoes* (1881); Bonney, T. G., *Volcanoes* (1912). The history of past volcanic activity in the British Isles is given in Geikie, A., *Ancient Volcanoes of Great Britain* (1897), a much larger work, with many illustrations.

(d) *Denudation and Deposition*.—The larger text-books generally include sufficient information about the work of the sea, of wind, and of rain and rivers, but if more be desired about glaciers and the work of ice, it will be found in Geikie, J., *The Great Ice Age* (1894), which represents the more extreme views on this subject, and Bonney, T. G., *Ice Work Present and Past* (1896), which, supplemented by his Presidential Address to the British Association, Report for 1910, takes the more moderate view. Modes of denudation generally are discussed in Avebury (Lord), *The Scenery of England and the Causes to which it is Due* (1904); Marr, J. E., *Scientific Study of Scenery* (1900); and Geikie, J., *Earth Sculpture* (1898).

(e) *Economic Geology*.—Marr, J. E., *Agricultural Geology* (1903); Watson, J., *Building Stones* (1911). If special information be desired on coal supply or water supply, in the one case consult the Royal Commission Report (Final Report, 1905), and in the other that on Water Supply (1869).

(f) *Palæontology*.—On Fossil Botany see Scott, D. H., *Studies in Fossil Botany* (1900), and Seward, A. C., *Links with the Past in the Plant World* (1911), a small but very interesting book. For extinct animals consult Woods, H., *Palæontology, Invertebrate* (1902), and Woodward, A. S., *Outlines of Vertebrate Palæontology* (1898). Another important work is Nicholson, H. A., and Lydekker, R., *Manual of Palæontology* (1889), and illustrations of the probable aspect of some of the more remarkable creatures of the past, with their history, are given in Hutchinson, H. N., *Extinct Monsters* (1910). The student who is collecting the fossils of a particular district will generally find figures and descriptions of these in the series of volumes published annually by the Palæontographical Society beginning with 1847. Palæontology and Archæology meet in Primæval Man, on which subject great advances have been made in recent years, so that we shall refer only to the latest work, *Ancient Hunters*, W. J. Sollas (1915).

(C) Geological Classics.—This title covers books which in most cases, though once making some great advance, are no longer, as is inevitable, on the level of present-day knowledge of Geology, or which have an historical character and describe stages in its development. Such are Darwin, C., *Geological Observations* (1876), embodying results obtained during the voyage of the *Beagle* from 1831 to 1836; Thomson, C. W., *Voyage of the Challenger in the Atlantic* (1877), the full results of which were published in a series of sumptuous volumes by a number of specialists; Lyell, C., *Principles of Geology* (1875), the first edition of which, published in 1830, did much to liberate the science from the fetters of traditionalism; Campbell, J. F., *Frost and Fire* (1865), a very suggestive, quaintly expressed book; Scrope, G. P., *Volcanoes of Central France* (1858), an account of a most interesting district, so exact as to be still valuable; Anderson, T., *Volcanic Studies* (1903), containing reproduced photographs of volcanoes in several parts of the world; Geikie, A., *Founders of Geology* (1905), a series of biographical sketches describing the development of the science; Evans, J., *Stone Implements* (1897), a book to which its numerous illustrations give a permanent value.

On many of the topics comprised in these three groups, and especially the second, much information will be obtained by consulting the articles under the several heads in the *Encyclopædia Britannica* and *Chambers's Encyclopædia*. In both works these are excellent, and though necessarily more concise in the latter, are not less useful to the ordinary student. The chapters on the geology of the several districts in the *Victoria County History of England* may also be consulted with advantage.[1]

1 If further knowledge be required, G. A. J. Cole, *Outlines of Mineralogy for Geological Students* (1913), will be found useful, or Hatch, F. H., *Mineralogy* (1912).

1 We may mention here, though it does not fall, strictly speaking, under any one of our heads, Jukes-Browne, A. J., *Building of the British Isles* (1911), because of its value in showing the application of Stratigraphical Geology to the history of a limited region.

Anyone desirous of acquiring a real knowledge of Geology must lose no opportunity of gaining it from outdoor observation. The study of fossils may, and to a great extent must, be carried on in the museum, but that of rocks, of earth sculpture, and other forces of Nature, demands work in the open air, and without that cannot be properly understood. Thus a student should arrange, whenever possible, to spend his holidays in some place which gives a good opportunity of investigating one or more interesting geological features, especially those which are not illustrated near his own home, in order that he may form clear ideas of what he has read of in books.[1] But even his own neighbourhood will generally offer more opportunities than he would anticipate for studying field-geology.

Almost all places provide "sermons in stones" and "books in the running brooks." Rainstorms illustrate the processes of denudation and the distribution of materials, the carving out of glens, sometimes even of mountain ridges, on mounds of earth and the slopes of embankments. Streams of any considerable length and strength show how angular fragments are worn down into pebbles. Beds of gravel, which often border valleys and even rise like islands from a fenland, offer problems always interesting, sometimes very difficult. The geologist should inquire from each different pebble in them: What are you? Whence came you? How were you made? and, What brought you here? The correct answers to these questions will help him much in ascertaining the past physical geography of his own district, and sometimes of no small part of the British Islands.

Beginners are attracted by fossils, for they gratify that collecting instinct which shows itself early, and often strengthens with increasing years. Rocks present more difficulties, for we cannot obtain an accurate knowledge of them without examining thin slices under a microscope, and making these is rather costly in time or money; but this form of investigation, since it is comparatively modern, still retains the charm of discovery. The study also of the mineral constituents of sands and clays is not less difficult or attractive. In short, there is hardly any district in our islands which does not offer work to the geologist, and it is work which increases the strength of the mind and the health of the body.

T. G. Bonney, Sc.D., F.R.S.

1 Much information about the geology of different districts will be found in Woodward, H. B., *Geology of England and Wales* (1887), and in *Geology in the Field* (1910), the Jubilee volume of the Geologist's Association, though one or two of its articles lose in value from the author assuming that his views on certain matters, still subjects of controversy, are beyond question. Help will often be found in Cole, G. A. J., *Aids in Practical Geology* (1902).

IX. BIOLOGICAL SCIENCE

BIOLOGY

I. AS THE SCIENCE OF LIFE

Nature of Biology.—In its widest sense *Biology* is the science of life. It is a study of the nature of life and of its origin. It investigates the working of the organism. It seeks to show in what way our present plants and animals have come to be what they are. It tries to answer such questions as: What are the characteristic properties of a being we recognise as "alive," which distinguish it from the inanimate objects that surround it? In what precisely lies the difference between, for example, the egg that is still capable of being hatched into a chicken, and the egg that has just lost that possibility? What is that property that we call the "breath of life"? And how is that property related to the physical and chemical reactions that go on constantly and intricately in every living organism, constituting the visible effect of its being alive? How did life arise? Did some external force superimpose it upon matter, adding thereby an entirely new thing? Or did matter rather gradually change, becoming associated with new types of energy which ultimately gave to it properties apparently quite strange to its original state? How, given the fact of some elementary form of life, of some organism far more lowly than any we know, how did the higher types arise, by what process was the giant redwood tree or the Siberian mammoth produced, and how, finally, did man himself come to be?

The Characteristics of Living Things.—The property of living organisms that is most obvious, that strikes the observer most forcibly, is that they have *form*. By form in this sense, we mean not only external shape, and colour, and consistency: we mean also internal structure, the architecture of organs, and the nature of the bricks of which these are built. Inanimate objects may have definite forms: salt separates from a solution in crystals of a characteristic shape; and shapes as definite as crystals but more plastic, and often resembling the shapes of living organisms very closely, can be obtained by the interactions of various liquids and jellies. We cannot state the possession of form as a logical and absolute distinction between the living and the non-living. But if we look in a little more detail at the properties of animate form we shall appreciate the fact that there is a difference under which lies something new.

We never have any difficulty in distinguishing say a speedwell from a buttercup; the creeping stem contrasts with the upright, the blue flowers with the yellow, the leaves are different. But though the speedwell exists for us as a plant with a well-defined and characteristic form, we find if we come to examine a number of specimens closely that no two are exactly like: the leaf-stalks vary in length, the leaves are frequently very different in shape, the colour of the flowers, and even the number of the floral organs, is inconstant. Speedwell and buttercup are formed in very different moulds, but in neither case is the mould rigid: it is elastic, and each separate individual finds in it a certain freedom. This is what we term *variation*. Slight differences crop up between the individuals of any species: *the form varies*. Of organic form we may say that it is characterised by an appreciable definiteness, so that the individuals of one kind appear to us as examples of a definable type, but that within these limits it always varies. A crystal too may vary in size, even in shape; but the characteristic feature of the crystalline form, or of inorganic form in general, is its mathematical constancy. The variations in this case are accidental and external, not fundamental and internal.

The Cell.—If we look further into the question of animate form we find that at the root of the comparatively simple external shape lies an extremely complex internal structure. All but the simplest organisms are built up of parts we call *organs*, each of which has its own peculiar function to perform; external shape is no mere cloak, hiding the activities of the interior—it is in part a result of the arrangement and relations of

the internal organs. We may carry our analysis of structure a step further, when we find that the organs are composed of *tissues:* the heart, for example, consists of tissues which we term *muscular*, *nervous*, and so on. That is to say there are different kinds of material making up the structure of an animal body, to one kind belonging the properties necessary to carry out the work of nerves, to another those which render muscles capable of contraction, and so on. These tissues are so arranged as to form the organs which carry on the various activities of life. But the most important step is taken when we go a stage further, and inquire into the structure of the tissues. For, different though these may be in function and structure, they are built up of units which have the same fundamental characters. In 1838 Schleiden discovered that plants were built up of *cells:* a year later Schwann extended the observation to animals. The cell is a little bag lined with a viscid fluid which is called *protoplasm*, and which we believe to be the actual living substance. The containing *bag* may be nothing but a skin on the surface of the protoplasm—almost like the skin that forms on cooling soup or porridge—or it may be a stout wall. Details on such points will be found in the articles on Botany and Zoology. Here it is important to know that plant and animal alike are formed of countless units of protoplasm, more or less sharply divided off from each other, which we term *cells*. Cells differ very widely in appearance and in function. The cells of muscular tissue are different from those of nervous tissue, and these again from secreting cells. Animal cells are quite unlike plant cells, and these vary according as they must carry water, or absorb light, or store food. And this statement brings us to the physiological side of the question, for it tells us that a tissue is fitted for the work it performs because the cells of which it is composed are fitted for that work.

Differentiation and Integration.—We must look at the cell from yet another standpoint. The simplest animals and the simplest plants consist of but a single cell. In such cases that cell must be capable of carrying out all the functions of the organism: it must be capable of moving, of absorbing food, of excreting waste products, and so on.[1] A little higher in the scale of evolution we find that the organisms are composed of several or many cells, and that these perform different functions: power of movement is confined to one set, of food absorption to another. In the higher plants and animals many different kinds exist, as we have seen. How does the higher organism come to have many cells? If we follow the course of its development we find that in every case it starts as one cell, and that as it grows that cell divides into two, these again divide, and so the process goes on. As the number of cells increases they begin to separate into the different sets with different functions which build up the complete creature. In the course of individual development, as in the course of development of the whole organic world, we start with a unit of living matter capable of carrying on all the reactions characteristic of living matter, and we proceed to many units of living matter separated into sets, each set capable of carrying on only certain well-defined processes. But always the different sets in an organism become more and more closely correlated, more and more dependent on each other, so that individuality does not become more vague, but more sharp. The detailing of separate functions to different sets of cells we call *differentiation:* the linking up of the different sets into one interdependent whole we call *integration*. As we rise in the scale of life we find these two always marching together.

For our present purpose the importance of the cell is that it is the unit of structure of the organism. At the base of our conception of all organic form lies this idea of a cell as unit, as a brick is the unit in the structure of a house: with this difference, that whereas the bricks only build up a *shell*, the cells build up an *organism*, the functions of which are carried out by the materials that go to the building.

Analogy between Animate and Inanimate matter.— If the first thing we note about a living being is its characteristic form, the next is assuredly its constant activity. By this we do not mean that it is continually in active movement, but that it is always carrying on one *function* or another. Food is absorbed, waste products excreted, movements take place, stimuli are perceived, growth occurs, and reproduction follows. The sum-total of such processes we designate as the "life of the organism." And in truth, the sum-total of these activities seems to be something different from any process of the inorganic world. Only when we come to look at any particular activity we find that it is impossible to distinguish it logically from some similar reaction that takes place apart from the presence of life. A bacterium perceives a stimulus exerted on it by meat extract, and reacts by swimming towards the stimulatory substance; but gunpowder equally answers the stimulus of a hammer stroke. It may be said that the organism responds in a way that is beneficial to itself, whereas the gunpowder is destroyed. We know cases, however, in which the bacterium swims into substances like carbolic acid, in which it dies. A plant moves towards the light, but sugar moves slowly through a glass of water till it is equally distributed in the liquid. And so with the other activities.

If we examine more closely the functions of an organism we come to more satisfactory results. As we have pointed out, in one of the

[1] *See below.*

higher animals or plants each particular function is relegated to a particular type of cell. As we descend the organic world we find that the simpler the organism the fewer kind of cells does it possess and the more varied are the functions of them. Finally we come to *unicellular* organisms in which all the functions are carried on by a single cell. Take, as an example, the *Amœba*. It is a lowly animal consisting of a single little mass of slime—the protoplasm, and yet it is able to carry out in a simplified manner all the characteristic activities of a living being. It moves over the substratum, half creeping, half flowing; from a dry spot it movesaway—responding to a perceived stimulus; it ingests food, and absorbs it; it gets rid of waste matter; it divides into two, and so reproduces. What conclusion can we draw from this? That all these activities are carried on by the substance of which the *Amœba* is composed, which is fundamental in it, as in all the cells of a more highly organised creature—the *protoplasm*. In it we may hope to find some hint of what lies below and causes all vital activity.

Synthesis of Organic Compounds.—Organisms are almost entirely built up of substances of extremely complex constitution, which occur nowhere in nature but in their association. We have *fats* and *oils*, *sugars*, *starch* and *cellulose*, *aromatic substances*, and *proteins*—such as white of egg. Of those the most important are the proteins: the sugars and oils are foods, the cellulose is protective, but the proteins actually build up and largely form the protoplasm; it is in the proteins therefore that those reactions take place which may be termed vital.

These *organic* compounds were thought peculiar to organisms, and even at one time believed to be produced only by the action of life. It is now many years since the first organic compound was prepared in the laboratory, and since that time more and more complex organic substances have been *synthesized*. In recent years we have seen the sugars artificially produced, and at the present day great strides are being made in the synthesis of the proteins. It can no longer be said that these substances are formed only by living organisms: some of the simpler, we have experimental grounds for believing, may be built up in nature, out of the laboratory and apart from life. As we shall see later, modern thought speculates with the possibility of the building up of even the most complex by purely chemical processes. But it is still possible to use the presence of some of them as a test, for we can say quite definitely that in the absence of proteins no life is possible: the *proteins* are the material basis of life.

Reproduction.—The organism is never at rest, it is always changing: life entails the doing of something; the doing is expressed as a change. The primary change that takes place whenever the conditions are normally favourable is *growth*. That growth may occur the creature must add substance to itself, and in so doing it performs the function of *nutrition*. The amœba is a little mass of protoplasm, and that it may grow it must make new protoplasm. It flows over the substratum and engulfs in itself small organic particles lying in its way, and these it first breaks down into simple compounds which it then proceeds to incorporate in its own living substance, building them up into new molecules of protein, adding them on to old ones, increasing their complexity. New protoplasm is constantly being formed and the size increases. A point comes when the size is unwieldy. It is difficult to nourish, because while the volume increases, the area of the surface does not increase so fast, and absorption is consequently not sufficiently rapid. It becomes increasingly difficult to regulate the activities of the growing mass. We suppose that regulation is largely the function of a little, rather solid knot in the protoplasm, which we call the *nucleus*. The nucleus cannot cope with the necessities of an indefinitely expanding amount of protoplasm. In short the whole organism becomes unwieldy and more and more unstable. Finally the instability conquers the coherence of the protoplasm, and the amœba divides very exactly into two parts, each with its own nucleus, and each half flows away on its own business. Here we have the function of *reproduction* in its simplest form, which is *division*. A little higher in the scale of life we find the single cell from which the organism starts going through the same process; but when division occurs, the two halves do not separate, they stick together. And as we go higher and higher we find the tendency of cells to stick together ever firmer, as we have seen accompanied by the tendency of the new cells to lose their general self-sufficient character, and assume special functions. In such cases special cells are set apart which ultimately break loose from the organism. These are the reproductive cells, and they possess the elementary general cell characters: but inside them is shut up some reminiscence of the whole organism, which we call *heredity*, for when, after their liberation, they begin to divide they produce cells not similar to each other, but different as those of the parent, building up an organism which is the image of its predecessors.

All the food that the protoplasm uses is not accounted for in growth; another fate is in store for much of it. The protoplasm does not merely add to itself, it also destroys itself, and it destroys much of its nutriment. Protoplasm is not only built up, it breaks down. This is seen in the excretion of waste products from the organism, chiefly in the form of carbon dioxide and simple nitrogenous compounds. The meaning of this process of wastage is that it supplies the organism with energy; energy expressed visibly in move-

ment, secretly in the carrying on of all the infinity of reactions which go to build up organic compounds. We know that when we burn a piece of wood we obtain energy in the form of heat, while the wood is converted into simple substances like carbon dioxide and water. Other organic substances are like this: they are stores of energy, and when they are broken down into simpler bodies, the energy is liberated.

A property of living organisms to which we have already made reference is their *irritability* or sensitiveness to stimulus. This, too, we can picture as a property of the proteins. The great size and complexity of the protein molecules gives them the opportunity of taking part in innumerable diverse reactions, but it also makes them very unstable. Slight changes in their surroundings produce deep effects, causing them to break up, split off parts, reform in various ways. It is thus that stimuli act. A ray of light, a breath of heat, a shock, a trace of a strange chemical, may set up new reactions in the protoplasm with far-reaching effects. This is perhaps best seen in specialised muscle cells. These are packed with highly unstable compounds, charged with energy almost escaping, needing only the slightest disturbance to set it free. A message comes from a nerve cell like a touch on the trigger of a gun: the stored compound breaks down—explodes almost—and the energy is liberated. It is this sudden liberation of energy that enables the muscle cell to contract, and so perform its work.

What then is the life of the organism expressed in terms of the activities of protoplasm? It consists in a ceaseless building up from food materials, and a ceaseless breaking down of elaborated compounds. The meaning of the building up is new *substance*, the meaning of the breaking down is new *energy*. With this substance and this energy are produced the outward and visible signs of life—growth and division, movement and chemical reaction. From the extraordinary complexity and associated instability of the protoplasm comes response to stimulus, the big result following the small cause. All life is change, and the fundamental change is change in the constituents of protoplasm.

Origin of Life.—Where did life come from? We know, as certainly as we can know anything not actually observed, that at one time the earth was a molten flaming mass. Through millions of years it cooled slowly till the crust was solid and cold enough for water to lie on it. Up till then nothing that we know as alive could have existed on it. Some time thereafter life started, and again through millions of years slow advance was made till the present flora and fauna were evolved. What was the nature of the beginning? It has been suggested that meteors flying through space brought life from other worlds; but that is only shifting the problem and not solving it, and it is besides very improbable. We discard the idea of a *creation* of plant and animal life; but we may still regard the problem as capable of two answers: (*a*) living matter arose slowly by the increasing complexity of non-living compounds, or, (*b*) some external and unknown force invaded non-living but very complex matter and endowed it with life.

We cannot go into details, we can only roughly sketch the way in which modern science regards the evolution of matter. It was formerly thought that all matter could be ultimately resolved into a definite number of elements—carbon, hydrogen, iron, sulphur, &c.—about seventy in all, combinations of which produced the variety of substances with which we are acquainted. The brilliant researches of a group of Russian and English chemists and physicists on radium and its allies has proved this to be a false, or at least an incomplete view. These investigations, taken together with the results of observations on the constitution of stars at different temperatures, have shown us the elements, in various stages of evolution from simpler and common states. We picture a primitive and all-pervading *ether*, without weight and without energy; we imagine its particles (if it be particulate) receiving charges of energy and becoming *electrons*; by further energy transformations the electrons unite to form the *atoms* of the simplest *elements*, and these elements we find in the hottest stars. In cooler stars more and more complicated atoms are formed and a larger number of elements comes into existence. Then as cooling proceeds the *atoms* of the elements begin to unite and we have *molecules* of compounds produced—hydrogen unites with oxygen and the face of a cooling world is enveloped with steam which ultimately condenses to water. Oxygen unites with iron and gives us rust; sodium unites with chlorine and we have salt. And the last stage is reached when molecules themselves begin to unite to form more complex bodies. When soda separates out from a solution it does not do so in separate molecules, but in crystals each made up of a vast number of molecules combined with a proportion of molecules of water. This salt *in solution* and other crystalline substances exist in the form of separate molecules or even break up into atoms. But inorganic substances exist which form molecular compounds even in solution, an example being the *water glass* that is used for preserving eggs. Some compounds of iron do so too, and many other cases are known to chemists. These are the highest and most complex states in which inorganic matter exists; we call them *colloids*. The evolution of inorganic matter is a continuous process from the lowest to the highest state, but when we have reached the end we have encountered no compound which we can call organic, which we

associate with plants and animals. Is there here a gap? Or is there a bridge between the inorganic and the organic?

Organic compounds all contain the element *carbon*, and to this they owe their possibilities of great complexity: for carbon is almost peculiar in being able to combine at once with four atoms of an element like hydrogen, whereas the majority of elements can only unite with one or two. For the building up of the carbon compounds another necessity exists, and that is a supply of external energy. In the animate world to-day all the organic compounds are formed in the first place by green plants which obtain their energy from sunlight absorbed by their green colouring matter. The problem is: by what means could energy be obtained before there were green plants? Within the last year or two it has been shown that certain inorganic colloids are able to do this: exposed to sunlight they are able to form simple organic compounds from carbon dioxide and water. That is the first stage: the exact details of the rest are not known to us, but we cannot now doubt that given the first simple organic bodies the building up of more and more complex substances takes place till finally there appear even the proteins, the material basis of life. The chain is complete, from ether and energy to formless protein.

But we are still left with the great and as yet unsolved problem: given *proteins of proper complexity and in a suitable state*, have we arrived at *life*? Here philosophers, and scientists too, disagree. For some would answer the question in the affirmative and say that all further developments are but the results of obscure changes in the protein compounds: while others maintain that at this point something new was added, though whither and how they do not know, and that to its working in the organism are due all those phenomena which we collect into one idea when we say the word *life*. In its most lucid form this view finds expression in the words of the French philosopher, Bergson: "*Life* is *consciousness* launched into *matter*."

Evolution.—In the further evolution of life two tendencies soon became manifest. Some primitive organisms acquired the green *chlorophyll*, and so became able to manufacture their own food from the simplest inorganic compounds —water, carbon dioxide, and a few salts. These compounds are present everywhere in damp spots, they do not require to be sought, and so the green organism came to settle down, losing its primitive power of locomotion. Its sedentary nature required no effort; its necessities came to it. It attained a very high degree of organisation, but it remained a complicated laboratory, which needed no guiding mind. So arose the vegetable kingdom. The organisms, on the other hand, that remained dependent on organic food, remained motile, for they must hunt for prey; as they became larger they required more prey and the hunt became more difficult. Success was not only to the quick, but also to the more conscious. Consciousness begat senses, and it finally produced the greatest triumph of all life—*mind*. And so arose the animal kingdom. In both kingdoms many side lines exist: but the main tendency of the plant with its chlorophyll was towards sluggishness, that of the animal towards vigorous movement and highly developed mind.

Heredity and Variation.—As to how the evolution has taken place, is taking place, we cannot say much here.[1] We have seen that in reproduction the organism has two properties: the one we call *heredity*, and it secures that the child shall be of the same type as the parent; the other is *variation*, and it secures that the resemblance is never exact—that round the central type there is always a play of new characters—usually extremely slight, but always occurring. With *variation*, evolution works. Charles Darwin saw the process as a constant selection of very slight variations, carried out because the stress of life is so great that only the organisms best fitted to their environment can survive. Any one which is even minutely improved on its competitors will tend to become the parent of the future generation. De Vries thinks that the larger variations which we call *sports* are the important material of selection. Lamarck, and after him Butler, imagined that the organism actively accommodates itself to its surroundings, and that the new characters so obtained are inherited. Bergson tells us of *life* as a *forward flow* or *impetus*, which triumphs over the resistance of *matter* and, branching and filling it out, *creates* new organic forms—resting places for a day in an ever-flowing stream.

We have tried to trace very briefly the way in which life has been produced and to show what is known of the more intimate processes which underlie its outward manifestations. It remains to add a word on the fate which ultimately befalls all living organisms—*death*. We imagine that it is an easy matter to recognise that state, and so it may be, in the main, when we are dealing with the higher animals. But even with them states are known in which no sign of life is visible though life is still present. The difficulty is much greater with simpler creatures. Cases are quite common, in which the organism literally turns to dust, and yet retains a spark of life ready to flame when the external conditions become more favourable.

Though it is often difficult to tell when death has occurred, we have some insight into its nature. We recognise in it a failure on the part of the protoplasm to cope with its functions, and that means an alteration in the nature of the protoplasm. It may come slowly as in old age, when it may

[1] See article Zoology.

be associated with a harmful heaping up of waste products, of which the organism has been unable to rid itself. Or it may come quickly as by a poison (the case of many diseases), when it is probably due to a rapid destruction of essential proteins. Perhaps the ultimate cause is a *coagulation of the proteins*—a process similar to the solidification of white of egg when it is boiled—a change to a state in which they cannot normally function, and from which there is no return.

II. AS REACTION WITH ENVIRONMENT. ECOLOGY

The term biology is frequently used in a much more restricted sense. If we speak of the biology of the mosses, or the biology of the seashore, or the biology of the seasons, we do not mean the complete study of all the aspects of life which may be associated with these phrases. We mean rather that part of the life which is expressed as reaction with the environment. To leave *biology* free to denote the larger science, a new word—*ecology*—has been devised to apply to the lesser. But it is not even now in general use, and so many books have been written in which biology means life in this special sense that we must devote a few lines to showing what kind of problem is here studied.

One moss—*Sphagnum*—grows in wet moors, another—*Tortula*—on the cement of walls: what in the organisation of these mosses suits them for such widely different stations? Anatomy and morphology tell us their structure; physiology tells us what can be known of their life from the physico-chemical standpoint; biology makes the attempt to relate facts thus ascertained to the conditions in which the plant finds itself. Or, more simply, it may content itself with noting these conditions, and observing how the organism behaves under their influence.

On a sheltered rocky shore we find an immense variety of plant and animal life. Systematic zoology and comparative anatomy have elucidated the structure and determined the relationships of the rockfish and the starfish, the lobsters and the worms, the periwinkles and the sea-spiders. Biology tells us how the hermit crab creeps into the shell of a whelk, and how very often a beautiful zoophyte covers the outside of this house; it watches the habits of the sea-spider and finds that when the eggs are laid the male takes possession of them and carries them about by a special pair of appendages, and it encounters the difficulty of finding these curious creatures, occasioned by their resemblance to the rocks and seaweeds on which they live. Biology watches the tints of the shanny changing with change of the colour of its surroundings; it sees the limpet fasten on the rock following an unskilful attempt to remove it. And so with the plants. The biologist finds that the different seaweeds occur in definite zones, some thriving in places where they are left dry and exposed to the sun for many hours, some luxuriating in deep, still pools, some suffering the beating of the surf. He sees the green sea-lettuce in shallow pools where the light is pure and bright, and the red seaweeds going down to the blue twilight of deep water; he knows that the reproductive bodies of some can survive in pools made fresh by the rain, while fresh water is fatal to others.

The seasons bring a never-ceasing change in the course of life. The wood hyacinth and the anemone flower before the foliage of the trees casts its full shade; the swallow and the cuckoo return to us in spring. In summer the green leaves absorb the sunlight that pours on them, and use it to form their food and the food of all animate nature: while from the innumerable blossoms of meadow and moor the bee sucks the nectar for its winter store of honey—the store destined to be pillaged by man. The willow-herb seeds float off to try their luck in new places, and the winged fruits of the maple dance in the autumn gales; the squirrel fills his granary with beech-nuts; the birds fly south. In winter vegetation dies down, animal life too largely vanishes; but the mountain hare and the ptarmigan who must run for food through months of snow change their coats from brown to white. These are events in the biology of the seasons.

Though we may regard the biology which looks at the intimate problems of life, and the biology which examines only its external manifestations as two distinct sciences—and indeed they stand far apart in method as in aim—it is more correct to treat them as merely different sides of one great problem. The analytical method of the anatomist and physiologist, of the physicist and chemist, has led us furthest in the appreciation of the ultimate causes of life, so far as these are at all susceptible to scientific investigation. But in the pursuit of these sciences we are a little apt to forget life in its broader aspects. In measuring the exact heights of a hill we forget the contour of the hillside; in analysing the pigment of a leaf we forget that fields are green; in looking at the structure of a bird's throat we neglect the orchestra of spring. The broader and simpler biology of the open country helps us to remember all this, and to keep our sympathies and imaginations open for the appreciation of general effects.

We must not study the complexity of protein reactions with such intensity as to forget the complexity of the inter-relations of living creatures. We look on protoplasm sometimes as a meshwork, a web, of protein and water. But there is another "web of life," a web with the most gorgeous pattern that has come within our ken: the pattern is never achieved, for the woof

is still running, and it changes before our eyes, always new, yet ever completely unified. The plants and animals of our globe may feed on each other, or fight each other, or love each other: but they all depend on each other. The life of one fits into the life of another, or rather into the lives of many others. No one is independent; all are linked and held as closely as the warp and woof of the web. And their lives together unite to give that pattern which is the pattern of the web of life.

COURSE OF READING

It is a somewhat difficult matter to devise anything like an elementary course of reading in general biology, for the simple reason that biology is not an elementary science. Take it from what side you will you are soon in the midst of philosophical discussions or of scientific problems of the most abstruse nature. An attempt to analyse life along scientific lines leads directly to a study of the changes in protoplasm. To appreciate this the nature and constitution of the proteins must be understood —a region of organic chemistry of which only the fringe has been explored.

The serious student will do well to make a start by reading two introductory books of somewhat different aim. In Prof. J. Arthur Thomson's *The Science of Life* he will find a general account of the problems connected with the subject. In scope it is somewhat greater than the outline we have sketched, but the chapters on the "Conditions of Life and Death," "Cell and Protoplasm," and "Embryology" are specially valuable from our present standpoint. The rest of the book gives a comprehensive survey of structure and function in both animal and vegetable kingdoms, of heredity and evolution, and of the relation of biological science to human activities.

The other introductory work is Benjamin Moore's *The Nature and Origin of Life.* It traces out the way in which the more complex types of matter have been evolved, and shows how matter sufficiently complicated to serve as a physical basis of life has arisen: and then it goes on to deal with the way in which functions are carried out and regulated.

A perusal of these two works will probably show the reader that much further advance is impossible unless the more fundamental sciences are first attacked. To gain some idea of the nature and reactions of matter apart from life the following books may be read. *Chemistry,* Raphael Meldola; *Inorganic Chemistry,* Prof. Baly; *Organic Chemistry,* Prof. Cohen; *Matter and Energy,* Prof. Soddy; *Sir William Huggins and Spectroscopic Astronomy,* E. W. Maunder; in these will be found special bibliographies. Chemistry, and especially organic chemistry, is a subject so difficult that only the closest application can lead to an understanding of it: and a considerable amount of general chemistry must be read before it is profitable to tackle the works on the compounds which are important to life. Reference may however be made to Longmans, Green's series of *Monographs on Biochemistry,* of which S. B. Schryver's *General Characters of the Proteins,* E. P. Cathcart's *Protein Metabolism,* and W. M. Bayliss's *Nature of Enzyme Action,* are specially important.

Turning to the actual phenomena of life we find an excellent account of work on the chemical side by Frederick Czapék—*Chemical Phenomena in Life.*

Verworn's *General Physiology* is a great work, in which vital activities are considered as functions of the cell. It is the best account we have of the fundamental activities that are common to all life, although it also takes up some which are characteristic of special types. Pfeffer's *Plant Physiology* is a physiology of the vegetable kingdom; but it is written with such breadth of view that it gives the reader Pfeffer's magnificent conception of the inter-relation of the reactions which goes to make up life.

Information on particular points may be obtained from books like W. Roux's *The Problems, &c. of Developmental Mechanics;* E. C. Wilson's *The Cell in Development and Inheritance; The Principles of Physiology,* J. G. McKendrick.

From philosophers the nature and origin of life has received much attention, and here it is only possible to mention one or two of the works which may be read: Spencer's *Principles of Biology,* Haeckel's works, and particularly *The Riddle of the Universe;* Hans Driesch's *Science and Philosophy of the Organism;* Bergson's *Creative Evolution.* Reference may be made to H. Wildon Carr's little book, *Henri Bergson.*

The problems of heredity and evolution are discussed in the article on Zoology, and books on them are given there.

On the aspect of biology which looks on the external manifestations of life we have a multitude of books. They are mainly semi-popular, and no attempt at a connected scheme of reading need be made. The reader simply selects books dealing with the branch in which he is interested. A few may be mentioned here.

GENERAL.—*The Natural History of Selborne,* Gilbert White; *The Book of Nature Study,* edited by J. Bretland Farmer (4 vols.); *The Biology of the Seasons* and *The Bible of Nature,* J. Arthur Thomson; *Nature Study,* John Rennie.

ANIMALS.—*Life by the Sea-shore,* Marion Newbiggin; *Ants, Wasps, and Bees,* Lord Avebury; all the works (on insects) of Henri Fabre; *Vegetable Mould,* Charles Darwin; *Study of Animal Life,* J. Arthur Thomson; *British Birds,* W. Pycraft; *The Childhood of Animals,* Chalmers Mitchell; *British Butterflies, British Moths,* R. South; *Life in Ponds and Streams,* W. Four-

PLANTS.—*Natural History of Plants*, Kerner and Oliver; *Rambles on the Riviera*, E. Strasburger; and see works on Ecology and Natural History in article on Botany.

TRAVEL.—The works of A. von Humboldt; *The Voyage of the Beagle*, Charles Darwin; the travel books of Alfred Russel Wallace and Edward Bates; also the works of many modern travellers, where, however, the natural history of plants and animals is usually subordinated to the study of the races of man.

For young people, two admirable series are in process of publication: Jack's Shown to the Children Series, Gowan's Nature Books, the former with coloured plates, the latter with photographs.

Further references to special subjects are made in the articles on Botany and Zoology.

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BOTANY

Botany, the study of plants and of plant life, has always been one of the popular sciences; the desire to know something of those dwellers in the woods and fields and gardens, which yield so much pleasure to our senses, has led many a flower-lover to the discovery of a fascinating hobby. A smaller band has found intellectual stimulus and satisfaction enough in the exploration of the problems of structure and mode of life with which the vegetable kingdom provides us.

Early History of Botany, &c.—The relation of mankind to the vegetable world is a very close one: plants are primarily food-stuffs and medicines, only secondarily ornaments. Even in the more favoured climes where man first arose, some sort of agriculture early became necessary to secure the requisite supply of food: and so began the study, at first doubtless unconscious, of the different kinds of plants and of their uses and needs. It must be supposed that the ancient civilisations of Egypt and India possessed a considerable and definite botanical knowledge: but the records have not come down to us nor do they appear to have been used by those Greeks who are the authors of the first botanical works still extant.

The writings of Hippocrates, 400 years before our era, contain lists of between two and three hundred plants, with notes on their medicinal value and with insufficient descriptions. About a century later Aristotle and Theophrastus doubled this number and made some attempt to explain the nature and mode of life of the vegetable kingdom. At the beginning of the Christian era Dioscorides and Pliny still further increased the list of known plants and gave accounts of their uses chiefly for medicinal purposes: and then for about 1500 years the study of botany, like the study of all other sciences, remained stationary.

In the sixteenth century the general revival of learning touched our science and awoke in it new life: a considerable company of competent workers started afresh to describe, name and arrange the members of the plant world, and the number of plants described increased continually. The fact that numbers of new and strange plants existed seems to have fired the imagination of nearly all the botanical scholars of the time, and consequently nearly all were engaged in the study of *systematic botany*, that branch of the science which deals with description and classification. This period culminated in the eighteenth century in the studies of the great Swede, Linnæus. His mind was capable of marshalling masses of facts in orderly array; he invented a system by which it was possible to classify satisfactorily the plants known to him, and in which the supreme importance of the characters of the reproductive organs found definite expression; he secured the universal adoption of a system of nomenclature by which a plant was fully designated by two names.

During this period a few isolated observers had laid the foundations of other branches of the science. The invention of the compound microscope made possible the study of *anatomy*—the internal structure of the plant; and some adventurous spirits attacked with success the fundamental problems of *physiology*—the investigation of the manner of living.

The first half of last century witnessed an unprecedented advance along all these different lines of research; the number of plants known and accurately described increased by leaps and bounds, knowledge of internal structure and of mode of life became ever deeper. There arose too the study of *life-histories*, the various stages passed through by a single plant during the course of its development.

Charles Darwin.—In 1859 Charles Darwin established the theory of evolution as applied to the organic world. A crushing weight of evidence was gathered together to show that the forms at present living on the surface of the earth have arisen by some process of change from forms previously existing, and these from still older types. The conclusion was that all our present organisms were descendants of some single simple ancestral being, and were therefore related to each other by community of origin. Further the process of change was intimately connected with an ever-increasing degree of *adaptation* to the conditions in which the organisms existed, and an explanation was given of the close connection between the structure of the organism and the way in which it lives.

Darwin's work revolutionised the whole outlook of the natural sciences, and since his time the work of the botanist has been more or less completely dominated by his views. The last half-century has witnessed increasing specialisation. More and more attention has been paid to special small areas of the science, and more

and more time and ingenuity have been employed on elucidating minute points of structure and life processes. But with the accumulation of details has gone an endeavour to relate the new knowledge to certain definite general principles. Systematic botany no longer aims merely at describing and classifying plants; it attempts to ferret out the real relationships existing between different plants and plant groups; while Anatomy and Physiology endeavour always to relate structure and life process to each other and to the life of the plant as a whole.

Connection between Botany and other Branches of Science.—Nor does Botany stand by itself: it is only one of a group of sciences, and every advance in the realms of physics and chemistry means an advance in the understanding of plant life.

We must not neglect to note that a further important aspect of the science, which becomes daily more prominent, is the economic aspect: particularly in the study of *plant diseases* and of *plant breeding* and also in the investigation of the best conditions of growth, does modern botany claim to aid civilisation in a very practical manner.

To sum up, we may say that the modern condition of the science demands, on account of the great mass of detail which has to receive attention, great specialisation: but that, as a whole, botany tends to possess an outlook increasingly comprehensive—philosophically in relating facts to each other, practically in aiding the production and cultivation of useful and beautiful plants.

We shall commence our more detailed discussion by considering

I. THE NATURE OF A FLOWERING PLANT

The most casual observation makes us all familiar with certain outstanding facts regarding the needs and structure of the common flowering plants. We know that to rear them successfully we must provide them with sufficient water, with a soil containing nutrient matter in the form of mould or manure, and that we must keep them in a situation where they have abundant air and light. We also know that commonly they possess a *stem* supporting the aerial parts; *roots*, which fix them in the soil and draw in water; *flowers*, which are responsible for the continuation of the race by producing seed; and *leaves*. The leaf is an organ to which superficial observation can assign no meaning, and yet in the function of the leaf lies the crux of the problem of vegetable life: we will turn first then to

A. The Leaf and its Work.—Although the variety of their forms is infinite, leaves possess certain features in common which are of great importance for the work they carry on. Almost invariably a leaf possesses a thin, flat, expanded portion which we call the "*blade*," and this may grow from the stem on a stalk, or it may rest directly on the stem. Further, leaves are almost always green in colour: the purple and red leaves of ornamental plants are really not exceptions to this rule. They too have green colouring matter, the presence of which is masked by an additional red pigment. If we look a little more closely we find that the foliage of a plant is always arranged in a certain definite manner, a manner which ensures that no one leaf shall shade another more than is necessary. An excellent example of this is the ivy. On a spray the leaves form a sort of mosaic so that an almost continuous green surface is spread out to the light, no leaf lying above another or shading it. The same is true of the branches of almost any tree or shrub or herb. This attempt of the plant to obtain a proper exposure to light is illustrated by another common occurrence: window plants invariably tend to grow towards the light, and if we wish them to be straight we must turn them round occasionally so that every side may be illuminated.

Necessity of Light.—Such observations seem to show that the leaf requires light: and, in fact, experiment has led to the conclusion that the work of the leaf is to *absorb light*. What is the meaning of this? To answer that question it is necessary to consider of what materials the plant is composed. If we take any common plant, say a grass, and dry it in an oven we find that in general it loses about three-quarters of its total weight: this loss is due to the escape of water, and thus that proportion of the plant consists of water. The quantity seems large, but it is frequently larger. In fruits and other juicy parts it may be as much as nine-tenths. If we heat the dried plant further more water and gases are given off and a charred mass is left, which we may call charcoal and which consists essentially of the element carbon—the chief constituent of coal. We can burn this charcoal, and we are left with a fine grey ash, weighing about one-fiftieth of the total mass of the plant, and containing various mineral substances such as potash.

Now the plant obtains its supply of water and also the constituents of the ash from the soil through its roots. But no carbon enters in this way: it is, in fact, possible to grow plants in soil entirely free from carbon in any form and yet to obtain a normal development. The only source from which the plant can draw its supply of this element is therefore the *air*. We are accustomed to regard the air as consisting of the two gases oxygen and nitrogen, and it must seem strange at first sight that the plant should be dependent for a supply of one of its chief con-

stituents on such a source. Let us remember, however, that a certain compound of carbon is continually being poured into the atmosphere in large quantities. This is the gas *Carbon dioxide* or, as it is sometimes termed, *Carbonic Acid Gas*. It is a matter of common knowledge that in respiring we inhale air containing much oxygen and exhale air containing much carbon dioxide. Thus the breathing of all human beings and indeed of all animals is continually supplying the atmosphere with carbon dioxide. Further, wherever burning is taking place oxygen is used up and carbon dioxide is generated: every fire and furnace and lamp is continually giving off the gas in question. The very fact that this continual production never leads to the presence of large quantities in the air (the actual amount is about 3 parts in 10,000) must lead us to the conclusion that some agency exists which is capable of removing carbon dioxide from the air as it is formed by respiration and burning. And, in fact, this agency is the green plant.

Carbon in Plants.—In what form does the plant possess *carbon?* Obviously it is not in the form of charcoal: it is combined in some way. It is found that all those constituents of the plant which are not purely mineral in nature contain this element in combination. This at once becomes clear when we remember that we can *char* all the products which we regard as typically vegetable in nature: thus, for example, wood, cotton, sugar, starch. And the process of charring consists in heating the substance in question till water is given off and charcoal or carbon is left.

Now if we burn say a piece of wood which contains carbon, there are produced carbon dioxide and a good deal of water in the form of steam and other vapours: we are left with ashes. But besides these substances, something more elusive is formed, to which we give the name of *energy*, and the energy takes the form chiefly of *heat*. The piece of wood contains ash, water, and carbon, which can be converted into carbon dioxide, and which in the process liberates a large amount of heat. That heat is in some way locked up in the wood only awaiting combustion to set it free. The wood (or any other vegetable product) is built up by the plant. To do this it has at its disposal water, and ash from the soil, and carbon dioxide from the air: but something is wanting. In order to convert the carbon dioxide into compounds with a store of energy, we must supply the plant with energy. This brings us to our original question—what is the use of the light? The light is the source of energy at the disposal of the plant for carrying on the conversion of the carbon dioxide. The green leaves absorb quantities of sunlight, and with the energy thus obtained they change carbon dioxide into the carbon compounds, which build up the plant body. The enormous importance of a suitable supply of light thus becomes clear, for without it the plant would be quite unable to form the compounds of which it is built up—plant life would be impossible.[1]

Structure of the Leaf.—We may now examine a little more closely the structure of the leaf. Very often it is possible to strip off from the two surfaces a thin colourless *skin* or *epiderm* (a Christmas Rose or Laurel may be tried): we are then left with a more or less fleshy, green central part which is traversed by the *veins*, a system of branching and interlacing fibres. It is interesting to compare the *venation* of different plants. It is found that those leaves which are more or less grass-like in form—*e.g.* lily, tulip, &c.—possess a number of more or less parallel veins which run from one end of the leaf to the other, not branching, but joined together by cross-pieces: broad-leaved plants, on the other hand, have a meshwork of much-branched interlacing veins.

The examination of a thin slice through a leaf by the microscope reveals the fact that it is built up of a very large number of minute boxes, the *cells*. It is important to be familiar with the structure of a cell, for it is to the plant what a brick is to a building. Every plant is built up of masses of cells. The typical cell is like a box limited on every side by a wall: the wall is made of a carbon compound, *cellulose*, familiar to us all in the form of cotton wool or paper. This wall is lined inside with a sheath of slimy fluid substance which is known as *protoplasm*, and which is the actual *living* part of the organism. Inside this sheath the cell is filled with a watery liquid, which serves to distend it, and which contains various nutrient substances. This *cell-sap*, like the *cell-wall*, is non-living: only the protoplasm is living, and in it take place all the processes actually concerned with the life of the plant. The protoplasm is not, however, a simple body: it constantly includes a little knot of denser material, the *nucleus*, the business of which is to regulate the activities of the cell; and it also frequently contains little masses of colouring matter. Thus the cells with which we are concerned, those of the core of the leaf, contain, embedded in their protoplasm, small biscuit-shaped bodies with the bright green pigment called *chlorophyll*, and it is to the presence of these in immense quantities that the leaf owes its green colour. The cells which build up the epiderm, on the other hand, contain no coloured bodies.

Shape of the Cell.—The shape of a plant cell varies greatly according to its position and uses. Those which we are considering are in form very much like short square bottles, flattened

1 The actual absorption of the light is carried on by the green pigment of the leaf—the chlorophyll.

at the points where they come in contact with their neighbours. Some idea of their size may be gathered from the fact that the leaf of any common plant—*e.g.* the beech—may comprise about six or seven layers of cells in its thickness.

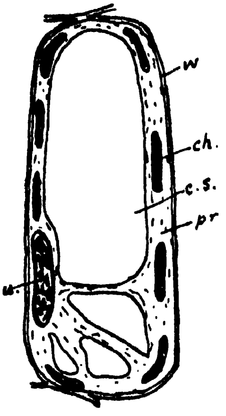

FIG. 1.—Cell of Leaf.
w., wall; *ch.*, chlorophyll body; *c.s.*, cell sap; *pr.*, protoplasm; *nu.*, nucleus.

The cells of the epiderm (which consists of a single layer) fit closely together, like the fragments of a mosaic, and thus form a continuous covering over the surface of the plant: but the cells of the core have gaps between them. They are joined together, but only by portions of their walls. All sorts of odd corners are left between, and these corners serve for the circulation of the gases which are so important—among others of carbon dioxide.

We have said that the epiderm is a continuous covering, and this might seem to be at variance with the necessity of having a supply of carbon dioxide inside the leaf. As a matter of fact, though, there are in the epiderm no irregular spaces between cells, there are instead a large number of slits, little openings allowing gases to pass in and out. These are the *stomata*.

With these facts in mind we can follow somewhat more closely the way in which carbon

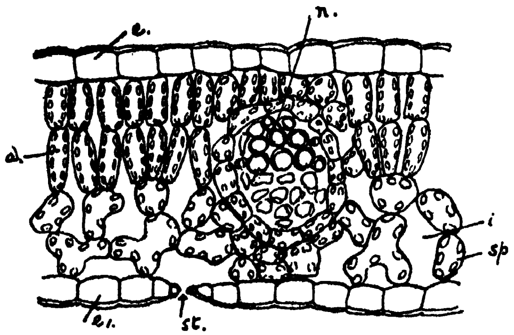

FIG. 2.—Section through Leaf.
e., epiderm; *n.*, vein; *i.*, intercellular space; *sp.*, spongy tissue; *st.*, stoma: *a.*, palisade tissue.

dioxide is used up—the process which is designated as *Photosynthesis*, the building up of organic carbon compounds with the help of light. The gas passes into the leaf by the stomata; it circulates in the spaces between the cells, and finally dissolves in water and enters the cells. Inside it comes in contact with the green pigment, and in presence of light and of moisture it becomes decomposed. This process results in the liberation of oxygen and in the formation of carbon compounds. It is quite easy to show

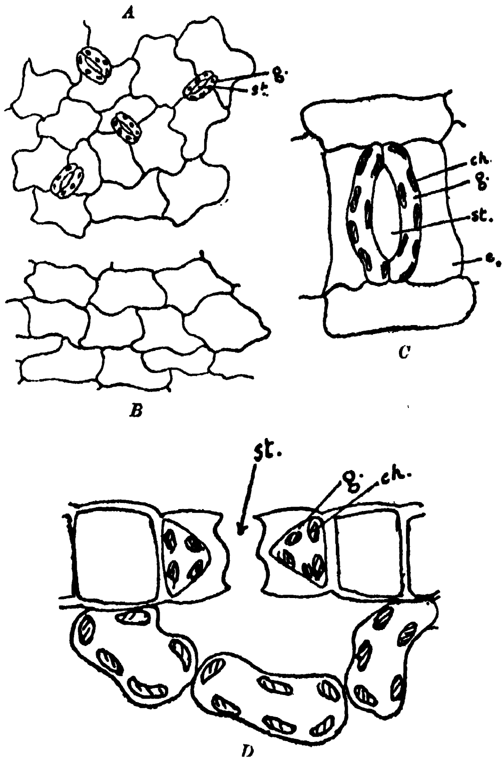

FIG. 3.
A, surface view of lower epiderm; *B*, surface view of upper epiderm; *C*, enlarged view of stoma; *D*, section through stoma; *st.*, stoma; *g.*, guard-cells; *ch.*, chlorophyll bodies; *e.*, epiderm cells.

that oxygen is given off. If we place a water plant in a glass of water in good light we see that little bubbles of gas are formed on it: these may be collected by suitable means and shown to consist largely of oxygen. The formation of the carbon compounds is also readily demonstrated. The compound which is most frequently produced is starch, and starch is easily recognised by the fact that it turns dark blue or black if supplied with *tincture of iodine*. If now we test with iodine a leaf which has been kept some time (a day or so) in the dark, we find that it contains no starch: whereas if we test a leaf that has been exposed to bright light for some hours we find that it acquires a deep blue colour, and that therefore it contains starch. A leaf kept in air which has been artificially freed from carbon dioxide forms no starch even in light, and this proves the necessity of the gas for the formation of organic compounds: the fact that

starch is produced only in presence of light shows the necessity of that form of energy.

Function of the Veins.—Another important function of the leaf must be considered. If we cut off a leaf and leave it exposed to the air, we find that first it *wilts*, and later on it *withers*. The wilting is due to loss of the water which distended the cells, and kept the leaf taut. Withering occurs when the leaf has dried up completely. This drying up or evaporation [1] of water must be constantly taking place under natural conditions, for the leaf is like a sponge soaked with water, which will always give off vapour as long as the air surrounding it is not quite saturated. While the leaf is still attached to the plant, or if it is placed in a glass of water, a sufficient supply of water enters it by the stalk to make up for this constant loss. The function of the veins is to act as a *conducting system* of tubes: they lead the water from the stalk and distribute it through the leaf. Further they gather up the carbon compounds the leaf manufactures and conduct them to other parts of the plant, where they may be required.

The Control of Evaporation.—At night or in damp weather a plant does not lose a great deal of water by evaporation; but in dry warm weather the loss may be very considerable. It may be so great astoexceed the supply, and when this is the case wilting sets in and the plant begins to droop. At such times we must resort to artificial watering of our gardens. But the plant itself has developed a number of means by which the transpiration is more or less kept within reasonable bounds. We have already noted the fact that the external skin of the leaves consists of a mosaic of cells which fit accurately into each other, with only occasional slits—the stomata—permitting gases to pass into and out of the leaf. In ordinary leaves which expose the upper surface to the drying agency of the sun we find the stomata restricted to the sheltered lower side. The exposed upper surface has few openings or none. And the protection is further increased by the whole of the surface of the leaf being covered with a delicate layer of wax which does not allow water to pass through it. When this waxy layer (*cuticle*) attains a strong development the leaf assumes a glossy appearance—*e.g.* the holly or laurel, the leaves of which are known to wither slowly. But the stomata, minute as they are, are so numerous that very large amounts of water vapour can pass out by them; in dry hot weather, dangerously large amounts. Now the stomata do not keep always open. As the quantity of water in the plant decreases the cells which border the tiny openings collapse, the opening closes, and further loss of water is largely prevented.

1 To evaporation of water from a plant surface the name transpiration is given.

Protective Adaptation.—The danger of excessive loss of water is most strikingly illustrated by the adaptations of such plants as grow in peculiarly dry situations, adaptations uniformly designed to guard against loss of water. Our own broom and gorse grow in dry exposed places, and in them we find the leaves small, or absent, or changed into spines; the green colouring matter is distributed in the spines or in the stems. The large evaporating surface of the leaves is got rid of, the plants thus avoiding the danger. More striking still are the cases of desert plants like the cacti: in them the stem is frequently large and swollen, acting as a water store: and at the same time the leaves disappear, and the work of absorbing sunlight is carried on by the chlorophyll of the stem.

In general let us note that whenever a plant is exposed to drought, it will tend to have small leaves. And it may also protect itself in other ways, as by the production of a very thick cuticle, or the hiding of the stomata in pits and furrows, where they are not subjected to the drying influence of the open air. Of course, the reduction of leaf surface goes hand in hand with a reduced power of absorbing sunlight, and we accordingly find that such plants are usually dwarfed or shrubby; they never attain the luxuriance of growth of plants with large leaves.

Function of Evaporation.—If then the plant possesses so many means of saving itself from the evil effects of loss of water, we may ask ourselves whether the giving off of water vapour is of any use. It is clear that the provision of stomata, which are necessary in order that the leaf may obtain a supply of carbon dioxide, entails the giving off of water: is this an unmitigated evil or has it any function? Some are inclined to think that the former is the case. But there are two ways in which evaporation of water may be useful. In the first place a plant exposed to bright sunlight is in danger of becoming overheated. And if part of the heat absorbed is used up in changing water into steam, which leaves the plant, then that danger is to some extent avoided. And then the loss of water from the leaves means that a stream of water is continually passing from the root through the stem to the foliage, and this stream carries with it various minerals which are required by the plant: the loss of water means then a more rapid transport of these important substances. In these ways the loss of water—which is in itself harmful—is of use to the plant.

It is easy to convince oneself that water does actually pass off from a growing plant: it is necessary only to place a potted fuchsia or pelargonium under a glass bell, and to observe that in a short time the inner surface of the cool glass becomes covered with dew. The actual amount of water given off has been accurately measured in many cases and is astonishingly

large. It has been calculated, for instance, that in the course of its five months' life a sunflower plant gives off 60 lbs. of water: while a beech tree gives 175 lbs. in one day—an acre of beech wood 1500 tons during the summer!

To sum up: we have seen that the leaf is a flat thin organ composed of cells, those to the outside acting as a protective covering, those to the inside important because they contain much chlorophyll. Its function is to absorb light by means of its green pigment, and with its aid to convert carbon dioxide into organic compounds. And since it must provide for the entrance of carbon dioxide, it must also allow water vapour to pass off, and so it assumes this further important function.

The leaf is, in fact, the factory or laboratory of the plant in which, under the influence of sunshine, those simple compounds which are taken in from the air and the soil are converted into the highly complex organic compounds—substances which are formed only in association with living organisms—which are the food of the plant.

The raw materials which come into this factory have already been mentioned. We have the carbon dioxide, which enters the leaf directly from the atmosphere, and, on the other hand, we have the water which passes into the leaf through its stalk. Further, we have dissolved in the water those mineral substances which are left in the form of a fine ash when the plant is burnt. The water and the mineral salts come from thesoil and they are absorbed through

B. The Root of the Plant.—If we pull up any common plant we cannot fail to be struck by the extent of the root system. Even insignificant herbs have often a mass of roots exceeding in length the aerial part of the plant, and consisting besides of an extraordinary number of small roots branching and spreading out in all directions. A plant growing for some months in a pot so fills up the space with roots that it almost appears as if the earth in the pot had been replaced by the root system. But the full extent of the root system can only be appreciated if actual measurements are made. Anyone wishing to spend an instructive and thoroughly tedious afternoon may be advised to pull up a wheat or oat plant, carefully wash out the roots and measure them all—including even the very small side-roots. The extraordinary number of these may be judged from the fact that a one-year pine seedling possesses over 3000 roots; the total length of the root-system of a mature cereal is about 500 yards. The volume of soil through which a sunflower plant may send its roots is more than 1 cubic yard.

We have seen what large amounts of water the plant contains and gives off; in order to provide the necessary large supply, this immense system of rootlets is sent branching in all directions through the soil, exploiting thoroughly every corner of it. For soil in good condition is never actually wet—it is only damp. It consists of little grains of *sand* round which are gathered smaller particles of *clay* and still smaller particles of *humus*—decaying organic matter. These do not form a homogeneous mixture; they are built up into *crumbs*; and soil in proper state is of a crumbly consistency. It is loose; it allows the free passage of air which the roots require; and it allows water to run through it, absorbing just enough to remain moist. Wet the soil thoroughly and it becomes a clogged pasty mass. Dry it thoroughly and it falls into a homogeneous dust. Any farmer or gardener knows how difficult it is to bring soil, which has once come into one of these conditions, back to the proper crumbly state which alone provides the roots at the same time with sufficient freedom to grow, with sufficient moisture and with sufficient air. Such generally favourable circumstances can only be obtained by restricting the amount of water in the soil to small drops that stick in the crevices between particles, and thin films that remain clinging round the soil grains. Toobtain a sufficientlylarge amount from such sources, the plant develops the system of roots we have just considered; these, branching through the soil in all directions, exploit every crevice and so attain their end.

Extent of the Root-system.—We find that the extent of the root-system varies with the necessities of the plant—that those which grow in very dry situations frequently produce roots descending to great depths, where water is to be obtained below the dry surface. Measurements have been made of roots descending to the enormous depth of 30 ft.; but growing in favourable conditions, the roots tend always to spread out in a mass near the surface; and so our forest beeches, or firs, when full grown send no roots to a depth greater than 2 ft.

In such cases the great roots spreading on all sides form a stand, as it were, embedded in the soil, on which the tree rests securely. That is the second function of the root system—to fix the plant firmly in the soil. The object is attained either by sending one long root with comparatively few side branches to a considerable depth, or by spreading out a very highly branched system near the surface. The former is probably the more effective: a high wind very readily blows over a tree like the shallow-rooted fir. We can see in any fir wood trees lying on the ground, the whole root system torn out along with the surface soil.

We have yet to see in what way the actual absorption of the water by the plant takes place. Even the finest side roots growing through the soil do not come into contact with the water so intimately as to absorb it efficiently. They touch the grains of soil, but they do not actually

enter the more minute crevices where the water chiefly lodges. Now if we sow cress seed on blotting paper and keep it moist for a few days, we find that round the young roots there is a white felt of tiny hairs: these are the so-called *root-hairs*. Each one consists of a single delicate cell, which grows out from the surface of the root into a fine tube. The root-hairs are produced about $\frac{1}{4}$ to $\frac{1}{2}$ inch behind the tip, and they die off an inch or so back. In the soil they grow round the grains into the smallest cracks, and so come into very close contact with the water films. At the same time they increase the surface available for absorbing water by a very large amount—on an average by about fifty times.

In the root-hair we have cell-sap, which is a

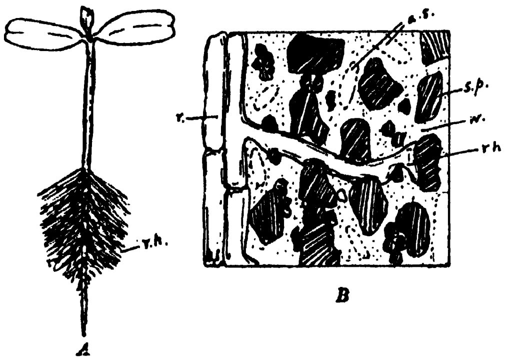

FIG. 4.

A, seedling showing root-hairs; *B*, root-hair in the soil; *r.*, cells of root; *r.h.*, root-hair; *s.p.*, soil particles; *w.*, water; *a.s.*, air-space.

pretty strong solution of various compounds. In the soil we have water, which is really a very weak solution of the mineral salts required by the plant—such substances as nitrates, phosphates, potash, sulphates, lime, &c., being present. Under such circumstances—that is when we have a strong solution separated from a weak solution by a membrane, such as the protoplasm of the root-hair—it is found that the stronger solution always draws water out of the weaker. And so it happens here: the strong solution in the hair draws in water from the soil, and thus it is that the plant obtains its supply. The mineral substances may and do pass into the root-hair too.

Absorption of Mineral Substances.—What are the mineral substances, and of what use are they to the plant? We have seen that when a plant is burned a white ash is always left, and that this is on the average about $\frac{1}{12}$ of the dry weight of the plant. This ash when analysed is found always to contain nine chemical elements—sodium, potassium, phosphorus, sulphur, magnesium, calcium, chlorine, silicon, and iron. But it does not follow that these are all useful to the plant. It is possible to grow plants in solutions containing compounds of these substances, and by trying different solutions, some with one, some with another element omitted, it has been determined that all are absolutely necessary except sodium, chlorine, and silicon. Moreover, the solution must contain nitrogen, which does not occur in the ash but passes off during combustion.

These elements have different uses. Protoplasm—the actual living part of the plant—is built up of compounds known as proteids, which contain in addition to carbon, oxygen, and hydrogen, always nitrogen and sulphur, and frequently phosphorus, potassium and magnesium. Iron and calcium, though not directly concerned in the building up of living matter, are absolutely necessary to plant life; the former has some sort of tonic action, the latter is an important antidote to various poisons.

In fertile soils all are present in small but sufficient quantity, and under natural conditions when a plant dies it returns its "ashes" to the soil. So also excreta and dead parts of animals yield their quota of mineral nutrients; soil water, slightly acid with carbon dioxide, dissolves the necessary elements partly from the rocks partly from these other sources, and the roots themselves excrete acids which aid in rendering available insoluble substances.

But under cultivation large quantities of ash are entirely removed with the crops: and as cultivated plants on account of their greater luxuriance require more mineral nutrient, they are soon confronted with a deficit in the supply. This must be made good by the farmer, who adds to his soil either farmyard manure—particularly rich in nitrogen—or various artificial manures. These are becoming more and more important. Superphosphate, kainit, and Chili saltpetre, to mention three of the best known, supply respectively phosphorus (and calcium), potassium, and nitrogen. The rational use of artificial manures is one of the most important developments of modern scientific farming: and the use of manuring lies in the addition of suitable mineral compounds to the soil.

Water and mineral substances are passed through the root to that part of the plant which connects the supply department with the factory.

C. **The Stem of the Plant.**—The stem, like the root, has to perform two main functions: it must support the leaves and flowers and it must conduct water and mineral salts upwards, and manufactured food-substances downwards. How it is able to perform these two tasks we shall best understand when we have looked at its internal structure; and this examination will at the same time provide us with an opportunity of seeing some of the different forms which cells can assume that they may be suited for different kinds of work.

If we take a young piece of the stem of a sunflower and make a thin slice or section of it in a

longitudinal direction, we find on examining it under the microscope that like the leaf it is built up of cells, and that these cells are arranged in groups : the cells of one group having a totally different character from those of the others.

To the outside we have the close fitting, colourless cells of the epiderm, many of which are prolonged outwards to form hairs clothing the stem. In the epiderm we have stomata scattered exactly as in the epiderm of the leaf. Next comes a layer of cells—the *cortex*—which resemble closely the spongy tissue of the leaf. They contain chlorophyll bodies and they take part in the production of food. Young stems are usually soft and green, and in that condition they perform the same functions as the leaves, though to a less extent because of their smaller surface. Occasionally this function of the stem is more important, as in those provided with broad " wings," *e.g.* the sweet-pea : or still more markedly in such plants as the broom, where the leaves are quite small and the stem takes over the larger part of their work.

Inside the cortex we find strands of cells which have become greatly elongated. The outermost of these we call "*bast.*" In the bast the most striking cells are those which form the "*sieve-tubes.*" These are rows of long cells, each of which is usually wide and well filled with a thick, viscid sap. The end walls of these tubes are pierced by a number of small holes. On looking down on such a wall it has the appearance of a sieve, and to it is given the name *sieve-plate*, while the term *sieve-tube* is derived from the same source. The effect of this arrangement is to make the cavity of one cell *continuous* with that of its neighbour, so that instead of having a *row* of *separate cells* we have a *tube*. Now the function of the sieve-tubes is the conduction of the manufactured food, and it is obvious that this can be carried on with much greater expedition if the substances in question are passed through a tube than if they must filter slowly through a number of cross walls from cell to cell.

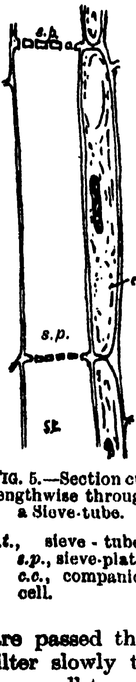

FIG. 5.—Section cut lengthwise through a Sieve-tube.

s.t., sieve-tube ; *s.p.*, sieve-plate ; *c.c.*, companion cell.

The sieve-tubes are embedded in a mass of cells like those of the cortex, except that they contain little or no chlorophyll. In fact all the special elements of the plant's structure are placed in a matrix of such cells which we may designate as *ground tissue*. And besides these we find associated with the sieve-tubes and, it would seem, regulating their activities, long narrow cells, the *companion-cells*.

Tissue of the Stem.—If we examine a thin cross section of the stem we gain further knowledge of the relative positions of these different *tissues*. To the outside the epiderm encircles the stem. Then comes the cortical layer forming a complete ring of several cells in thickness. We can see, however, that the cells of the cortex are not all of the type described above. In the corners of the stem are blocks of quite a distinct character. The general shape is the same, but chlorophyll is absent, and if we look closely we can see that the cell wall has become much

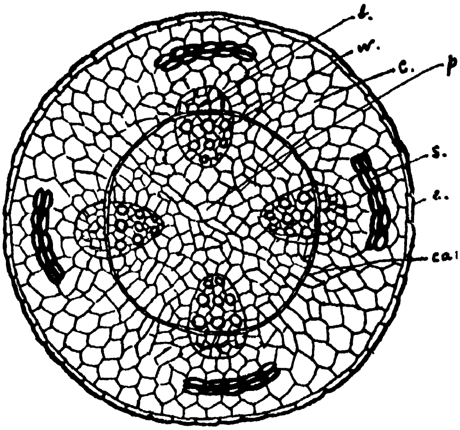

FIG. 6.—Cross Section of Young Stem.

b., bast ; *w.*, wood ; *c.*, cortex ; *p.*, pith ; *s.*, strand of wood in fibres ; *e.*, epiderm ; *cam.*, cambium.

thicker than that of the other cortical cells. At the corners of the cells great masses of cellulose have been added, so that the cavity has assumed a diamond shape and is no larger than the thickened part of the wall. These are cells which have taken on a special structure to serve a special function : they form a *strengthening tissue*, and to the extra thick wall they owe their extra strength.

Inside the cortex is the bast, but the bast does not form a complete ring. It occurs as a number of strands between which run bands of ground tissue connecting the cortex with the *pith*. This latter consists of a core of large, thin-walled cells which fills up the centre of the stem. To the inside of each strand of bast lies a strand of *wood*. This double strand forms what is termed a *fibro-vascular bundle*.

To understand the nature of the wood we must turn again to the longitudinal section. Here we see that like the bast it consists of very long cells ; but there are three great differences. (1) The cells contain only water and air, no living matter —they are dead tubes. (2) The walls are very much thickened, and no longer consist of cellu-

lose, but have become converted into a much stronger and more resistant compound—in fact into *wood*.

The thickening of the walls of the wood cells

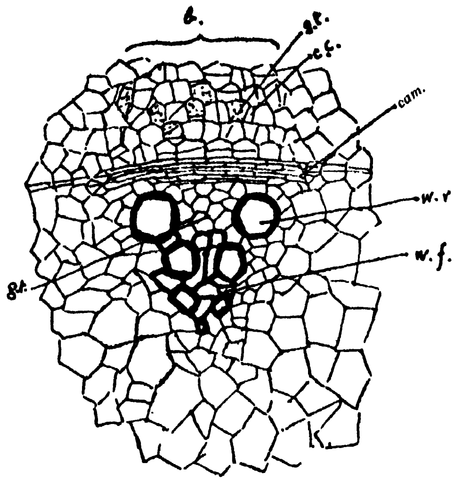

FIG. 7.—Enlarged Cross Section through a single Fibro-Vascular Bundle.

b., bast; *s.t.*, sieve-tubes; *c.c.*, companion cells; *cam.*, cambium; *w.v.*, wood vessels; *w.f.*, wood fibres; *g.t.*, ground tissue cells in the wood.

is peculiar. The wood has two functions: it conducts water to the leaves and it is the chief strengthening tissue of the plant. If water is to

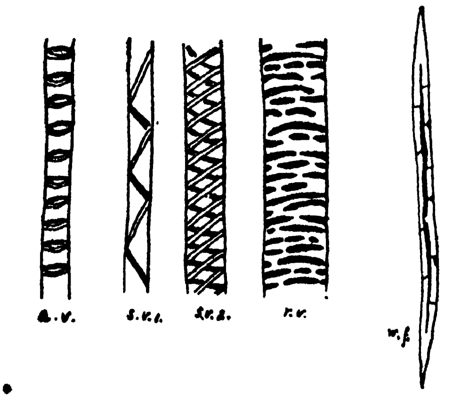

FIG. 8.—Types of Wood Cells.

a.v., vessel with ring-like thickening; *s.v.* 1, vessel with a single spiral thickening; *s.v.* 2, with two spirals: *r.v.*, vessel with netted thickening; *w.f.*, wood fibre with very thick wall and very narrow cavity (dark); the fine black lines represent narrow pits or thin places in the wall.

pass readily from one cell to another the walls should be thin. If great strength is to be attained the walls should be thick. A compromise is struck in two ways. Some of the cells take on the form of "*wood fibres*"—long and pointed, with extremely thick walls and almost no cavity. These are concerned only with securing strength and do not aid in conduction. Others are much wider, and possess walls which are thickened only here and there. The thickening may take the form of a spiral, of rings or bars, of a mesh: or only small oval or circular *pits* may remain thin. In all cases the aim is the same; the thickened portions yield strength, while through the thin parts water may pass with comparative ease. (3) Further, these water-conducting cells very frequently fuse together, the end walls entirely disappearing. Our trees very generally possess such *vessels*, as the rows of fused cells is termed, with a continuous cavity of about 4 inches long, while the length of the individual cells which build them up may not be more than $\frac{1}{25}$ of an inch. In tropical climbers with extremely long and thin stems, where the task of carrying water to the leaves is much more difficult, we find these vessels extending to the relatively enormous length of 3 to 5 yards. One great class of trees—the conifers—does not possess vessels, but only elongated cells with numerous pits in their thickened walls. And we note that the conifers also possess those small needle-shaped leaves with thick cuticles which help to economise the water supply. This may be partly due to the fact that they are evergreens and can obtain their water supply in winter only with difficulty; but it is probable that the necessity for economy is also partly forced on them, because of the difficulty of transporting water rapidly through a stem with no true vessels.

Besides wood-fibres and vessels we also find ground-tissue cells in the wood. These serve as stores, both of water and of various food substances.

Cambium Tissue.—One other tissue of great importance is found in the stem and also in the root. If we take a young twig, especially in spring-time, we find it very easy to peel off the "bark." If we examined a section of such a twig under the microscope we should find that the splitting takes place *between* the wood and the bast: and the splitting takes place so easily because at that point there is a ring of very delicate cells running right round the stem. To this ring is given the name *cambium*. Its special property is that it retains the power of growth and division. Whereas wood and bast are fully formed and consist of cells which cannot divide, the cambium is in a state of active growth. Its cells are continually splitting off new cells, sometimes to the outside sometimes to the inside. Those to the outside develop into bast, those to the inside into wood. But always between the two there remains the delicate cambium ring which is neither bast nor wood, but is capable of giving rise to both.

In this way the stem or root grows in thick-

ness. As the cambium is a continuous ring it follows that soon, instead of separate strands of wood and bast, we have a central cylinder of wood, surrounded by a hollow cylinder of bast. This is the case in all those plants which possess a cambium. Plants which possess no cambium are only such as live for a short time—a year or less—showing no increase in the thickness of the stem after it is fully formed, and able to meet their necessities with the wood and bast in the original bundles. And to these we must add those plants which belong to the great group of the *Monocotyledons*—such as the grasses, the bamboos, or the palms. In these the bundles, instead of being arranged in a ring, are scattered through the stem irregularly. No cambium is present, and any growth in thickness which occurs is due to increase in size of individual bundles.

But, with these exceptions, in all our British plants a cambium is present, and to its activity is due the gradual increase in thickness of the stem or trunk. The activity is greatest in spring, and then are formed the largest and widest vessels. Towards autumn the vessels formed are narrower, and are accompanied by a greater number of wood fibres. The contrast between the autumn growth of one year and the spring growth of the next produces the appearance of concentric rings seen on the trunk section of a felled tree. As a rule one ring is produced every year, and so we can tell the age of the tree.

Looking at the section of a felled tree we see not only the concentric annual rings but also fine lines radiating from the centre towards the circumference. These are the *medullary rays*—rows of ground-tissue cells, some stretching from pith through wood and bast to cortex, some extending for shorter distances in the wood. Through these water and food-stuffs can pass radially in the stem; they also act as stores.

Storage of Food.—The necessity for storing food exists in all flowering plants at one period or other of their lives. The thick stems of our forest trees contain innumerable ground-tissue cells in which starch is packed away in summer and remains stored up during winter. In spring the starch after being converted into sugar is rapidly conveyed to young growing parts and there aids rapid growth of branch and leaf and even flower (the sloe is covered with blossom before the leaves appear) before the leaves have fully expanded, taken on their deepest summer green, and commenced to manufacture new food at high pressure. Plants which last more than one year but do not possess the mighty trunk of the tree store up food in other places. Many garden plants the stems and leaves of which die down in autumn have fairly thick roots or under ground stems which may be used for storage. But most interesting are those in which special storehouses are provided.

Thus the *crocus* has a ball-like underground stem or *corm*, the primrose a thick upright *stock*, while the swollen underground stems of the ferns and wood anemone are horizontal and called *rhizomes*. The *tubers* of the potato are also specialised stems. In the turnip, carrot, and beet we have cases where the main root has become a massive store; the *clubs* of the lesser celandine are side-roots. *Bulbs* are collections of modified leaves and commonly contain much sugar; the hyacinth, snowdrop, and onion are well-known examples. And even the flowers may store up food—the head of a cauliflower is a collection of these which perform this function alone and no longer set seed.

In plants which last only one season the storage of food takes place only in the seed, which contains in all cases an embryo plant with almost always a supply of food sufficient to give it a proper start on germination.

It is easy to prove that the wood is the part of the stem concerned in conducting water. If we place a cut branch in water the leaves remain fresh even though the bark and pith be removed. Only if the wood is cut out does wilting occur. Much more difficult is the problem of the force which is responsible for raising the water to the tops of trees. That the force must be considerable is plain when we remember the large quantities of water required, and the great height to which it must be raised. We are not yet in a position to explain completely the way in which this "*rise of the sap*" occurs, but we know that various forces are concerned. There is *capillarity*, by which we mean the drawing up of liquid in a narrow tube. The narrower the tube the greater the height to which the liquid rises, and as the vessels of the wood are narrow water must rise in them for this reason. Then we have *root pressure*. Many plants if they be decapitated, especially in early spring, show "bleeding" from the stumps, and frequently the exuded sap is pressed out with considerable force. This is due to the pressure exerted from the cells of the roots, and may assist in pushing the sap up the stem. *Leaf suction*—suction due to evaporation from the leaves and consequent concentration of the solution in their cells—pulls up the water, acting from above, and certainly plays a very important if not the most important part. And finally it is thought that the living cells in the wood perform a sort of pumping action known as *wood-lift*.

In trees it is usual to find that only the youngest—external—part of the wood carries water. It is known as the *sap-wood*, as distinguished from the *heart-wood* at the centre. In the heart-wood the passages are more or less clogged up, while the walls become impregnated with resinous stuffs. To this and to the absence of water is due the advantage possessed by heart-wood over sap-wood in the matter of strength and durability.

Summary of Vegetative Activities.—The activi-

ties of the plant may be divided into two main sets, "vegetative" and "reproductive." The first set may be regarded as paving the way for the second. So far we have been concerned with this first set, and we may now sum up our various points and use the opportunity to fill up gaps in the statement.

The most prominent manifestation of vegetative activity is growth, and growth requires food-stuffs and energy. Into the root pass minerals and water, and through the wood of the root[1] and the stem they are carried to the leaves. There the water meets with carbon dioxide and in the presence of light and chlorophyll sugars and starch are formed and oxygen is liberated. Large quantities of water pass off into the air via the stomata.

The sugars and starch we may regard as the true foods of the plant. They may be used up where they are formed or they may be transported through the sieve-tubes of the bast to growing parts or to storage tissues. The food substances may be used in two different ways. They may be built into the structure of the plant. So sugar is converted into cellulose and forms new cell walls, and so it is combined with nitrogen and other ash elements and formed into the complex proteids of which the living matter of the organism is composed.

But in the second place the food substances are a source of energy. We have seen how in being built up they receive a quantity of energy from sunlight. This remains locked up in the organic compound, and may be liberated in various ways. For instance, when we burn a piece of wood we reconvert it into carbon dioxide and other simple compounds and liberate its stored energy in the form of heat. The plant requires a supply of energy: it requires energy to increase in height, to force its roots into the soil, to raise water, and to carry on innumerable chemical reactions bound up with its life. It finds the energy locked up in its food-stuffs and liberates it by the process of *respiration*. Respiration in plants and animals alike consists in uniting organic compounds with oxygen. They are converted into the simple compounds like carbon dioxide and water exactly as in burning, and again a supply of energy is liberated. Part of the plant food thus is being continually sacrificed in respiration for the sake of the energy it contains.

The intense importance of the process of photosynthesis will begin to be apparent. Not only does it result in a supply of food, it results also in a supply of energy; and so all the energy of the plant is derived from the sun. But we must remember that in the last instance all *our* food—as the food of all animals—is derived from plants. If you eat beef or mutton, the ox or sheep ate grass. If we live on fish, we live on marine plants. And our bodily heat and our energy come from our food. Further, almost all the energy which is important in civilisation is obtained in the last instance by burning coal or oil—coal the remains of long-dead plants, oil the debris of ancient fishes. Animal life and human life depend on the fact that plants are green, and our civilisation, built up on the exploitation of energy supplied us by fires, rests on that foundation too. The sun in the last resort is the source of all life. Photosynthesis by green plants is the keystone in the arch of nature.[1]

The plant grows, using up food-stuffs in the process, and when it reaches maturity it reproduces its kind. The flowering plant does so typically by setting seed—in this the flower plays the chief part. But the process is a complex one, which will be better understood after we have glanced at some other types of plant life.

II. THE ASCENT OF PLANT LIFE

We have seen that the flowering plants possess a structure of extraordinary complexity, which enables them to live with success on land, where the supply of water is restricted, and where they are subjected to a multitude of other influences, good and bad, met on the part of the plant by adaptations, utilising the useful and counteracting the mischievous. These represent the highest stage of development reached in the vegetable world to-day, the result of many millions of years of slow evolution. Vegetable life began with something simpler, and only very gradually did more and more complex forms arise. Meanwhile the simpler types did not entirely disappear: they were superseded but not entirely supplanted, for they remained the organisms best fitted for some places in nature, and they also fill up gaps in the places which are inhabited by the higher types.

So we find that the sea is still inhabited almost entirely by seaweeds or *algæ*, the surface of stones gives a refuge to the lichens, and on the barks of trees algæ and lichens flourish, while ferns and mosses thrive in dark corners of the wood and in cracks of the rocks. Another line has been followed by the fungi—toadstools, mildews, rusts—for they have lost their chlorophyll, and their power of making food, and have come, like the animals, to batten upon the living green plant as *parasites*, or on its dead remains as *saprophytes*.

It must not be supposed that those representatives of the lower orders we have still with us are the forms which long ago gave rise to successively higher stages in the evolution of the vegetable kingdom. The actual ancestors of our

[1] The internal structure of the root is very similar to that of the stem.

[1] Electricity obtained from water-power does not come to us by way of the plant, but it too depends on the energy (heat) of the sun, which raises the water as vapour.

higher types have probably all long since disappeared: for, even with the help of fossilised remains of plants no longer existing, we cannot trace the exact line of descent of the seed plants from the next lower classes—the ferns, far less from their remote ancestors—the algæ. What we possess are culminating points of side lines which have led no further—pools left in the track of a flood that has swept on to the ocean. These lower types show us the *general trend* of evolution, not its *exact course*.

A. **The Algæ.**—Sometimes the water in a horse-trough or small rain-pool takes on a greenish colour, and this, as examination under the microscope shows, is due to the presence of innumerable minute algæ. One of the simplest of these is *Chlamydomonas*. It is a small pear-shaped organism in which a single mass of protoplasm is surrounded by a delicate membrane. From the more pointed end project two minute lashes, *cilia*, which whip the organism through the water. The protoplasm is provided with a bell-shaped chloroplast, and with a nucleus. It also has a spot of red pigment in front and in the chloroplast a clear place in which starch is stored—the *pyrenoid*. Cell-sap is contained in two pulsating vacuoles.

The plant is extremely simple in so far as it consists of a single cell: it is a unicellular

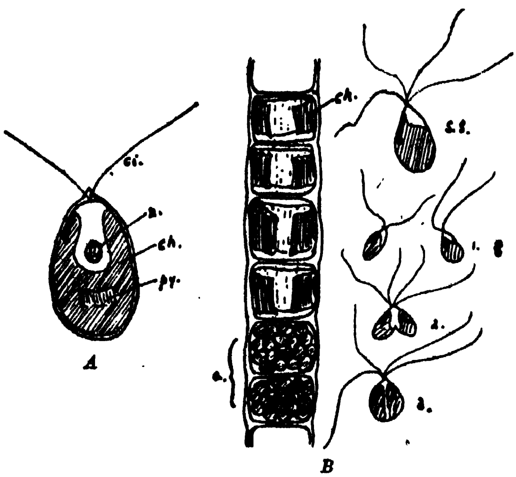

FIG. 9.—*A*, Chlamydomonas; *B*, Ulothrix.

ci., cilia; *n.*, nucleus; *ch.*, chloroplast; *py.*, pyrenoid; *s.s.*, swarm-spore; *g.*, gametes in three stages of conjugation; at *a.*, two cells in which gametes are being formed.

organism. But we may note that that cell already contains all the parts characteristic of the cells of the higher plants. *Chlamydomonas* swims about in the water manufacturing food and in consequence increasing in size. Now it seems that for any cell there is a definite limit of growth beyond which it cannot go. This is determined by various factors. As the volume increases it does so more rapidly than the area of the surface, which consequently becomes less and less able to absorb an adequate amount of raw material and to dispose sufficiently quickly of waste products. And then it is probable that the nucleus can regulate efficiently only a certain volume of cell-substance. Consequently a point comes at which further increase is impossible; and this is true for the cells of higher as of lower plants. Here the process of *cell-division* takes place and two or more new cells are formed.

Reproduction.—This process, which results in the formation of new individuals, we call *reproduction*. In the simplest case in *Chlamydomonas* the protoplasm divides into two exactly equal halves. Each of these receives an equal part of the various cell organs, and proceeds to form a new wall and new cilia, and then escapes from the wall of the "mother" cell as a new individual.

Sometimes in *Chlamydomonas* new individuals escape from the mother cell without forming walls, and such are incapable of further growth unless they undergo a further process. They must fuse with each other in pairs. In such cases they are given the name of *gametes*, and the union of two such gametes is the first stage in the development of *sexual reproduction*. The fused gametes settle down as a little spherical mass, form a thick wall and rest for some time, and then germinate, producing several new *Chlamydomonas* individuals.

When a *Chlamydomonas* individual divides each of the daughters becomes an independent organism, and we never arrive at a stage possessing more than a single cell. This is not always the case, however. The alga *Ulothrix* commences as a free-swimming unicellular body very much like a large *Chlamydomonas*. This settles down after swimming about for a time, loses its cilia, and then proceeds to divide into two. But in this case the two halves do not come apart: they remain fixed together; and when they divide their daughters also remain fixed together. As the divisions all occur parallel to each other the result is a long hair or *filament* of cells joined end to end. These filaments of *Ulothrix* are common in briskly-running streams attached in tufts to the stones. Each cell of the filament contains a band-shaped chloroplast and a nucleus. Reproduction in *Ulothrix* takes place in two different ways. One of the cells may give rise to a *spore*. A spore is a general term for a unicellular reproductive body produced by a multicellular plant and capable of giving rise directly or indirectly to a new plant. In this case as the spore has four cilia and is thus motile it is spoken of as a *swarm-spore*. The swarm-spore, as we have already noted, gives rise to a new individual—and this is

asexual reproduction. Or a single cell may give rise to a number of bodies exactly like the swarm-spore except that they are smaller and possess only two cilia. These are gametes, and after conjugating (fusing) in pairs they settle down to rest, later on giving rise to a number of swarm-spores, each of which develops into a new *Ulothrix* filament. This is *sexual reproduction.*

Algal Developments.—The further elaboration of the algæ takes place in various ways. The flat, leaf-like, green fronds of the Sea Lettuce, which are common on any sea shore, may be looked on as threads of *Ulothrix*, the cells of which have divided lengthwise as well as across. So we progress from the single cell to the filament and to the *thallus*—a thallus being a flattened more or less leaf-like expansion of cells which does not as a rule possess an internal structure of anything like the complexity of a leaf. The cell filament need not remain simple; it frequently branches, as is the case in *Cladophora*, another alga common both in fresh water and in the sea. In *Cladophora*, too, we find the beginnings of a difference between neighbouring cells. All look alike, and yet it is only those at the tips of the branches that can divide—the others do not possess that power.

We must mention two other lines along which algal development has proceeded.

(*a*) In many cases *Chlamydomonas*-like cells do not separate from each other after division, but remain more or less loosely attached, and form plate-like or spherical *cell-colonies*. The most advanced of these is *Volvox*, which may occasionally be found in bogs, in the form of little motile spheres about the size of a small pin head. Each consists of thousands of minute cells united in a jelly by delicate threads of protoplasm.

(*b*) Filaments may be produced in which cell-division is absent. In such cases the nucleus divides many times, so that the long tube-like filament contains numbers of nuclei. *Vaucheria*, a common alga on damp soil, consists of branched filaments of this nature. In warm seas forms of great outward complexity with this internal structure are found.

The most complex algæ are found in two classes which are almost exclusively confined to salt water, and to which the names "red seaweeds" and "brown seaweeds" are given on account of their prevailing colour. They possess pigments which, while differing in appearance and composition from chlorophyll, perform essentially the same work. The brown seaweeds attain greatest luxuriance in cold, the red in warm seas. In both classes we have simple filamentous types and branched filamentous types; but the majority are much more complex. They grow as a rule by the continued division of an apical cell: the daughter-cells divide in all three directions and in consequence a thallus is formed. This may be differentiated into shoot-like and leaf-like parts. Internally it frequently possesses cells adapted for conduction, others for food-building, and so on.

These highest forms of algæ have thus advanced a long way from types like *Ulothrix*, but they still fall far short of the complexity of flowering plants, for the reason that, living in water, they are confronted with none of the problems of supply and economy which are solved by the adaptations of the land plant.

Sexual Reproduction.—Reproduction in the algæ is not always of the simple type described for *Ulothrix*. Asexual reproduction is generally exhibited in some simple form—by the formation either of motile swarm-spores, or of non-motile spores which drift about in the water. In sexual reproduction, however, important advances take place. The first of these is that the two gametes become different: this is the beginning of "sex" in the strict sense of the term. One gamete becomes large, well-stocked with food-stuffs, and loses its power of motion—it is henceforth designated the *egg* or *ovum*. The other tends to diminish in size, retains only the minimum of food for a short independent life—it ultimately loses its pigment and power of forming food for itself, but it remains actively motile. It is termed the *sperm*. The egg is the female element, the sperm the male. The advantage secured is that the egg is able to obtain superior nutrition, while the task of bringing male and female elements together is confined to the sperm. The possibility of reaching the egg is attained by the motility of the sperm, in conjunction with the fact that the egg often exudes chemical substances which attract the sperm, and so guide it to its destination. The chances of the egg being fertilised are immensely increased because the plant usually produces innumerable sperms for each egg. Hand in hand with all this goes a tendency to produce the ova and sperms on separate plants.

Further developments take place. We have already seen that in *Ulothrix* the fertilised ovum does not germinate directly into a new plant, but divides first into swarm-spores. It becomes more and more the tendency of the fertilised ovum to give rise to something different from the plant which produced it. This reaches its climax in some of the red seaweeds. *Polysiphonia* is an example. It is a very common alga seen in little crimson tufts attached to stones and to other plants in our rock pools. The fertilised egg here produces a plant which is to all outward appearance the same as the plant which bore it. But this plant never produces either eggs or sperms: it only gives rise to non-motile spores. These spores in turn give a plant which produces only sexual organs and never spores. Here we have an example of an organism

which in the course of its life shows an "*alternation of generations.*" A sexual generation alternates with an asexual generation. If we start with an egg-cell, then we must pass through two generations before we again have an egg-cell produced. This principle attains an immense importance in the higher plants, where we must accord it further attention.

Significance of Sexual Reproduction.—At this point we may refer briefly to the significance of sexual reproduction, and to the advantages it affords the plant over the very much easier and safer process of asexual reproduction. The chief point of sexual reproduction is that the nucleus of one gamete fuses intimately with the nucleus of the other, and that from this "fusion-nucleus" arise the nuclei of all the cells of the new plant. When the nucleus of a cell undergoes division, it is found that the denser matter in it gathers into a thread, and that the thread breaks up into segments—so-called *chromosomes*—the number of which is always constant for any particular species of plant. Each of these segments proceeds to halve longitudinally, and one-half of each segment passes into each of the two daughter nuclei. In this way each daughter obtains exactly one-half of the original nucleus. It will be seen that in sexual reproduction the fusion nucleus would come to possess double the number of chromosomes proper to the species. The plant developing from the fertilised egg-cell would possess the double number of chromosomes in all its cells: when next sexual reproduction occurred the succeeding generation would possess four times the proper number of chromosomes: with each new generation the number would be again doubled. This does not occur because always at some particular point of the life cycle a peculiar *reduction* division takes place. In it half the chromosomes pass to one daughter cell, half to the other. Thus in a plant with ten chromosomes the ordinary division will result in ten half chromosomes passing to each new cell: whereas the reduction division will produce two cells, each with five whole chromosomes. The order of events is thus: *Sexual Reproduction — Reduction Division — Sexual Reproduction—Reduction Division*, and so on. From the reduction division till the fertilisation of the egg-cell the number of chromosomes may be called x: from fertilisation till the succeeding reduction the number will be $2x$. According to the point of its life history at which we examine it, the plant will possess x or $2x$ chromosomes. The reduction division provides a mechanism whereby the continued doubling is obviated.

Another fact must be noted. The sperm, we have said, tends to become smaller and smaller—in many cases it consists practically only of a nucleus. Yet in all cases the sperm exerts the same influence on the character of the new plant as does the ovum—paternal characters are as well represented as maternal.

The elaborate nicety with which the nuclear contents are divided into two equal lots during division, and the fact that the sperm, with almost nothing but nucleus, transmits the characters of parent to offspring, lead irresistibly to the conclusion that it is the nucleus which is responsible for the transmission of hereditary characters. This gives a clue to one meaning of sexual reproduction—it will result in the mixing together of the characters of two different stocks, and the opportunity thus given for new combinations of characters may be of advantage to the plant.

A second result of sexual reproduction is that the union of the egg and sperm gives more vigorous life to the stock produced.

Even in the algæ, then, the lowliest members of the vegetable kingdom, we find beginnings and hints of the most important developments of the higher orders. We have the differentiation into assimilating leaf and supporting stalk. We have the formation of conducting and assimilating cells; and, on the other hand, we see the origin of sexual reproduction and its developments into a sharply defined process, and the beginnings of an alternation of generations.

B. **The Fungi.**—The next great group of plants is one which stands no higher in degree of organisation that the algæ. But it has strayed into side ways and acquired a mode of living quite different from that described as typical for plants. The fundamental point is that the fungi have lost their chlorophyll: they are colourless, or provided only with pigments which are unable to utilise sunlight for building up organic foods. In consequence the fungi are wholly dependent for their food supply on materials already elaborated by other plants. They may obtain their supplies in two different ways. They may attack living plants (or animals) in which case we speak of them as *parasites*, or they may live on the remains of dead organisms, when they are known as *saprophytes*.

Perhaps the most familiar of the fungi are saprophytes. We may give two examples. The common "blue mould" (*Penicillium*), which is often found forming a layer, leathery below and dusty above, on the top of jam in pots, and which appears on almost any damp organic matter, from bread to old boots, is a fungus with a simple organisation. Colourless, many-celled, branched threads ramify over the surface of the nutritive medium. Reproduction takes place by a peculiar kind of spore. Filaments, branched near the apex like a candelabrum, are sent into the air. From the tip of each branch successive small pieces, which take on an oval or spherical shape, are, as it were, "cut off." These are the spores. They are produced in vast numbers—the whole of the greenish surface dust of the mould con-

sists of quantities of spores which measure about $\frac{1}{3000}$ in. in diameter. These spores are asexually produced, and they differ from the type of asexual spore most typical of the algæ (swarm-spores) in two respects. They have a firm cell-wall and they possess no cilia. This is related to their production in air instead of in water. They are distributed passively by air currents, and they require the protection against drying-

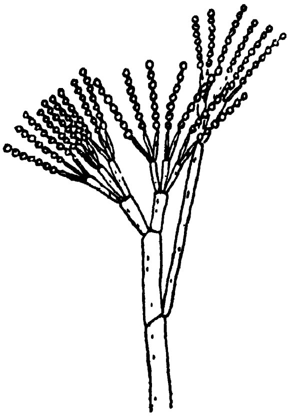

FIG. 10.—The Blue Mould producing Spores.

up afforded by a more or less firm cell-wall. How thoroughly they are distributed is shown by the fact that it is impossible to leave a damp piece of bread lying about in an inhabited region without its becoming infected with a growth of some sort of mould in a day or two.

The Mushrooms and Toadstools.—The most familiar of all the fungi are the mushrooms and toadstools. They, too, are saprophytes. In the soil in which they grow they produce an immense system of branching filaments which absorb nourishmment from decaying organic remains—dung or leaves, for example. The formation of the sporing-body commences underground, and not till it is fully formed and supplied with nutrients does it appear above ground. It then does so with the extreme rapidity which has become a byword. The sporing-body possesses the greatest complexity of structure found in the fungi. The stalk bears an expanded cap, on the underside of which are radiating gills which bear the spores. In the young stages these are frequently protected by one or two membranous coverings. Internally the filaments are differentiated considerably, and we find special tissues for conducting food, for protection and for bearing spores. The spores are produced in immense numbers, and are again distributed by air currents.

Those fungi which are parasites are of great economic interest, as they are responsible for many important diseases of the higher plants and even for a few in man.[1]

The *mildews* are fungi which cause diseases of many cultivated plants, *e.g.* the rose. Besides producing spores similar to those of the moulds, they have a well defined type of sexual reproduction. The *rusts* attack many cereal crops, and cause immense damage. They, too, have sexual reproduction, and in their case it is part of a well-defined alternation of generations. An interesting feature of the rusts is that in many cases the sexual stage attacks one species of higher plant while the asexual stage can only live on a second. Thus the rust of wheat is the asexual stage of a fungus of which the sexual fructifications occur on the barberry.

Other fungi are known which live in water, and they resemble the aquatic algæ in producing swarm-spores. We have every reason for believing that the various classes of fungi have developed from various types of algæ. which have first become partially and, through loss of their chlorophyll, have finally become totally, dependent on external food supplies. In fact we know algæ that at present occupy an intermediate position.

The physiology of the fungi is extremely interesting: on the one hand they are able to utilise very different food substances, on the other they form many peculiar products. We must content ourselves by noting that such diverse substances as sugar, wood, and paraffin are used up; and that among important products are vinegar and alcohol. The yeast plant is a fungus which converts sugar into carbon dioxide and alcohol, a process the economic importance of which is sufficiently obvious. The use of alcohol and such products to the plants themselves lies in the fact that they protect them from the competition of other organisms.

Bacteria.—Here, too, we may mention in passing the *bacteria*, which are fungi of a very simple type. They cause numbers of diseases; but they are also essential in nature in breaking up organic waste and so rendering it available for the nutrition of other organisms.

The *Lichens* are a peculiar class of organisms. They are formed by algæ and fungi living in so intimate a partnership as to form well defined new types. The alga cells lie embedded in a matrix of fungus filaments. The former supply the partnership with organic food, the latter absorb water and mineral salts and protect against drought. A partnership of this kind, which results in a benefit to both organisms, is termed *symbiosis*. Other examples are known in the vegetable kingdom, but the lichens form the only case in which the union is so complete that an apparently new organism is produced.

[1] Some of the moulds are responsible for injuries to the eye and throat, and a lowly fungus causes *actinomycosis*.

In all the others, the one partner is predominant and retains its own typical form.

The lichens are the outposts of vegetable colonisation. Their slow growth, power of resisting drought, and modest requirements enable them to occupy the most unpromising stations, tree trunks and rock surfaces, where no other type of life could succeed.

C. The Mosses.—The mosses form a class of a very much higher type than the algæ. They must have arisen from these, but all attempts to find out from what line of algal descent they have taken their origin have led to very unsatisfactory conclusions. The mosses are divided into two main sub-classes—the *liverworts* and the *true mosses.* The true mosses all possess distinct leaves and stem. Many liverworts have an undifferentiated thallus. This distinction, however, does not hold absolutely, for many liverworts have stem and leaves. In the case of these the classification rests on rather technical details into which it is unnecessary to go.

The mosses show comparatively little variation in essential structure, and in especial their mode of reproduction is very constant. The moss *Polytrichum,* very common in damp shady woods, where it forms deep soft cushions with its upright stems, may be taken as an example. The stem may be as much as a foot long. It contains conducting tissue of elongated cells, which are, however, not nearly so specialised as those of the flowering plants. There are no true roots, but the base of the stem bears tufts of *rhizoids.* These are like root hairs, but consist of several cells. On the rest of the stem the leaves are arranged in a spiral. They are small, pointed, and only one layer of cells thick, except along the mid-rib. In *Polytrichum* the mid-rib bears curious flat plates of cells elevated above the surface which serve to increase the area exposed to light. Many mosses have leaves uniformly one cell thick. At the apex of the stems are borne the sexual organs. In this case male and female organs are on separate plants. In some mosses both occur on one individual. The egg-cell is enclosed in a peculiar flask-shaped receptacle called an *archegonium,* while the sperms are formed many thousands in a sausage-shaped *antheridium.* In order that fertilisation may take place, the surface of the moss must be covered by a film of water such as obtains after rain-fall. The sperms can then swim about, and if any chance to come into the neighbourhood of an archegonium they are directed to its opening by the stimulatory effect of a sugar which it excretes. When the fertilised egg-cell develops, it does not give rise to a new moss-plant; instead, it forms the well known "moss-fruit"—a little capsule or *sporangium,* with a hairy cap, in which are produced spores. The spores are liberated by the opening of a lid, and germinate to a green branching filament very like an alga: from buds on this grow new moss-plants.

Here again we have an alternation of a sexual with an asexual generation, and in this case the two are widely different. The moss-plant is the sexual generation with archegonia and antheridia: the "moss-fruit" the asexual generation with a sporangium. The asexual plant lives as a parasite on the sexual. The reduction in the number of chromosomes takes

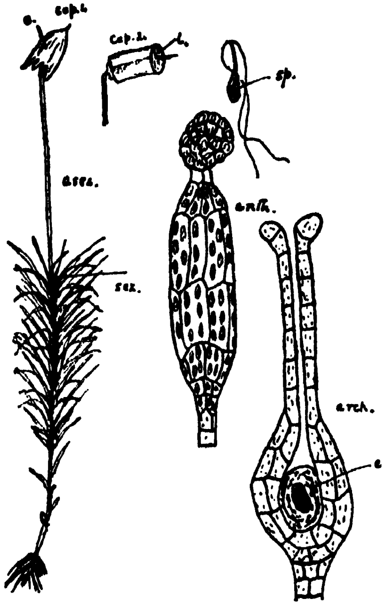

FIG. 11.—Moss.

sex., the sexual plant; *asex.*, the asexual plant with the sporangium cap; *c.*, the cap; *cap.* 2, sporangium with the cap removed to show the lid *l.*; *anth.*, antheridium with ball of sperms just escaping; *sp.*, a sperm; *arch.*, an archegonium; *e.*, the egg-cell or ovum.

place here, and in all the higher plants, during the formation of the spores. So it comes about that in the *sexual* generation (beginning with the spore) we have half the number of chromosomes present in the *asexual* generation which starts with the union of sperm and ovum. The relation of the two may be made clearer by the following scheme of development.

sexual generation:
spore — x chromosomes
moss plant
archegonium — antheridium
ovum — sperm

asexual generation:
fertilised ovum — $2x$ chromosomes
moss fruit
sporangium
spore ← *reduction of chromosomes*

Liverworts.—Of the liverworts we may mention *Pellia*, a common form in damp positions, particularly about the banks of woodland streams and ditches. It is a somewhat branched green thallus with wavy margins, bearing rhizoids on the lower surface and on the upper sexual organs like those of the moss. The spore-producing generation has a slender stalk and a sporangium like the head of a large pin. The spores give rise directly to a new sexual plant. As has been remarked, some of the liverworts have differentiated stem and leaves.

The mosses again represent a side-line. They appear to have led nowhere, for it is not apparent how the higher plants could have originated from any of the types we know.

D. **The Ferns and their Allies.**—We come now to a class which is on the same plane as the seed-plants as regards the complexity of structure in its members. The fern-stock is a very ancient one, for among the earliest fossil plants which have been sufficiently preserved to admit of accurate study are included primitive types of ferns. It is surmised that these were evolved from algæ, but the intermediate steps are wholly wanting.

The number of ferns in our present vegetation is insignificant compared with that of earlier geological times, when they and their allies were the dominant types; but they are still so abundant that their general features are familiar to us all. They are on the whole inhabitants of moist stations—for a reason that will appear later. The stem is typically a thick horizontal stock which lies at or near the surface of the soil, and from which fibrous roots descend. It has embedded in its ground tissue fibro-vascular bundles of a structure nearly as advanced as those of the seed-plants; but they have neither cambium nor any true vessels: the conduction of water takes place through a series of wide empty cells which communicate by numerous pits with very thin walls. From the stem arise the fronds or leaves. These are usually very much divided—a fact to which they owe their graceful appearance. The leaf has much the same structure as the leaf of a seed plant.

The reproductive organs occur on the back of the leaf, forming what is commonly (and erroneously) termed *fern seed.* The numerous little brown patches consist each of a group of sporangia, frequently protected by a scale. Each sporangium contains numerous spores. The fern is thus a spore-bearing plant reproduced asexually. The spore on germinating gives rise to a tiny heart-shaped green thallus, and on the lower surface of this are borne archegonia and antheridia, on the same plant. Here, too, the sperms must swim in a film of surface water to the egg-cell. For this reason the ferns are confined to such situations as are rather damp, where the necessary water will not fail. From the fertilised egg-cell develops the fern-plant. Here we again have an alternation of generations, the asexual plant being the more important, the sexual comparatively insignificant. The reduction in number of the chromosomes takes place when the spores are formed.

Allies of the Fern.—Amongst the fern allies we reckon the *Horsetails* with their erect stems frequently bearing many circles of branches, and tipped by a cone of sporangium-bearing scales: the *Club-mosses* with prostrate stems covered with small green pointed leaves: the *Water-ferns*, aquatic, frequently floating types sometimes to be seen in hot-houses: and *Selaginella*, a delicate green trailer, frequently cultivated as an ornamental house plant. The difference between these in appearance is very great, yet anatomically they stand about the same level, and their reproduction follows a common scheme.

In the method of reproduction, however, great advances are made by some forms, of which we

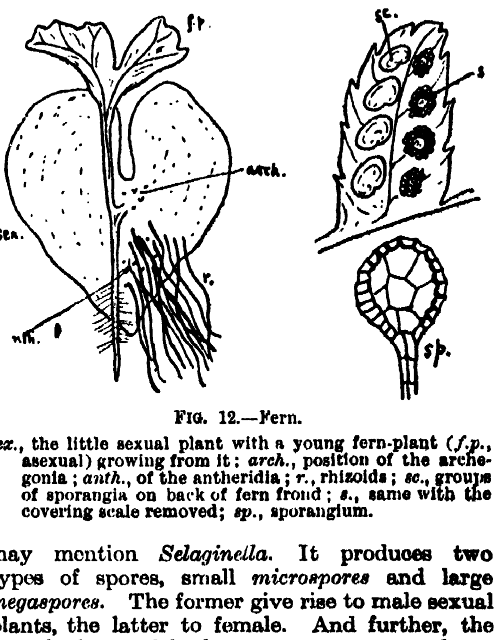

FIG. 12.—Fern.

sex., the little sexual plant with a young fern-plant (*f.p.*, asexual) growing from it; *arch.*, position of the archegonia; *anth.*, of the antheridia; *r.*, rhizoids; *sc.*, groups of sporangia on back of fern frond; *s.*, same with the covering scale removed; *sp.*, sporangium.

may mention *Selaginella*. It produces two types of spores, small *microspores* and large *megaspores*. The former give rise to male sexual plants, the latter to female. And further, the sexual plants of both types are very much reduced as compared with that of the ferns proper. The male plant consists of a very few cells which remain entirely inside the microspore. The female plant only protrudes slightly as a little green tuft from the split wall of the megaspore. This tendency to reduce the sexual generation and make the asexual generation all important is one which has become more and more marked in the higher plants until it reaches its climax in the seed plants to which we now turn.

The Seed Plants.—These include two subclasses. The *flowering plants* are not only the most numerous in point of species, but are also

the most characteristic and prominent constituent of the vegetation of the present day. Well over one-half of the total number of plants known to-day are flowering plants. The second sub-class is less important than it was in former geological periods, but it is still considerable, and of great economic importance. We may call it the class of *cone-bearers*, though that name is not exact as applied to some of its members.

The cone-bearers are of a simpler type than the flowering plants, and we may take the *Pine* as an example. The pine, like the fern, is an asexual plant. In spring it produces two kinds of sporangia, one with megaspores, the other with microspores. The familiar *cones* are collections of scales, each of which bears at its base two *megasporangia*. In the seed plants the megasporangium receives a special name: it is termed the *ovule* or, in the much more expressive equivalent of the German, the *seed-bud*—for it gives rise to the seed. The ovule consists of a little mass of cells surrounded by a protective covering. In it a single cell, in the formation of which the number of chromosomes has been halved, is the spore. And the spore never leaves the parent plant: it remains embedded in, protected, and fed by the tissues of the ovule.

The sexual generation is extremely reduced. Inside the spore-cell a little mass of tissue is produced, and in it a few very simple archegonia are formed. The sexual generation is thus not only entirely confined to the spore, but it is even embedded in the tissues of the spore-bearing generation, by which it is nourished.

Pollen.—The *microsporangia* occur in pairs, little sacs on the lower surface of yellowish scales, arranged in small cones. The microspores are formed in immense numbers, and are known in the seed plants by the name *pollen*. The pollen when liberated is scattered by air currents. So abundant is it that if in spring a pine-branch bearing pollen be shaken, the air becomes charged with a sulphur-yellow dust. Of the myriads of grains formed, a few will reach their destinations —the ovules. The male sexual plant is even more reduced than the female: it consists of two or three cells, one of which gives rise by division to two male cells. The male cells are no longer sperms—they have no cilia. But from the pollen grain grows out a long *pollen-tube* which burrows through the tissue of the ovule until it reaches the egg-cell. Down this travel the male cells, and one of them which alone is functional fertilises the ovum. It will be seen that a great change has taken place in the manner in which the male cell reaches the female cell. Instead of swimming thither, it is carried passively. This is of immense importance, for it means that it is no longer necessary for the plant to live in a station where surface water will be available for the sperm to swim to the ovum. The plant is liberated from the absolute necessity of having water at one particular period of its life-history—it is free to inhabit the "dry land" in the widest sense of that phrase.

The fertilised ovum gives rise to a new plant. This develops until it possesses a tiny root, stem, and a few leaves, surrounded by a tissue derived from the cells of the female plant and full of stored food. All this takes place while the young plant is still connected with the parent, and the result is the formation of a *seed*. The seed is surrounded by a hard *seed-coat* which comes from the covering of the ovule. When the seed is fully formed, the young plant ceases to grow and enters on a period of rest. At this point the seed breaks away from the parent tree, and becomes independent. Seeds are generally formed in summer and autumn, and then, after being scattered by various agencies (in the pine by the wind), remain dormant till the following spring, when they germinate and produce a new plant. The great importance of seed formation lies in the fact that the whole of the development of the female sexual generation takes place in connection with the parent spore-bearing plant, and it is thus well protected and well nourished: and further, that the young spore-bearing plant which takes origin from the fertilised egg-cell is placed in a position of similar advantage. It is able to develop until young roots and leaves are formed before it is set adrift; and when the separation takes place, it is provided with a food store on which it can draw when germinating, until it is in a position to manufacture food for itself in sufficient quantities. We may formulate a scheme of the life-history of a cone-bearer as we did for the moss:

asexual generation:
seed with embryo
pine tree
cone — cone
microsporangia (pollen-sac) — megasporangia (ovule)
←*reduction of chromosomes*→
pollen — embryo sac

sexual generation:
reduced male plant — reduced female plant
male cell — egg cell

embryo in seed

The difference between this and the history of an advanced fern type such as *Selaginella* is immense. There, although we find already two kinds of spores, the development of the female plant takes place entirely separated from the parent, the sperm must swim to the egg-cell, and there is no seed formed.

Even among living plants we find some which indicate how the gap was bridged. The *Cycads* are a small group allied to the cone-bearers, growing in warm climates. They have leaves reminiscent of fern leaves, and although the

male cells are carried to the female by a pollen-tube they are provided with cilia. Among fossil plants many intermediate types are found. At one period of geological history the most prominent feature of the vegetation was a class of plants fern-like in appearance, but producing typical seeds, and supplied with a cambium by which the thickness of the stem might be increased. Such links show how the cone-bearers may have arisen from remote fern-like ancestors.

The formation of seed and the carriage of the pollen grain by agencies which dispensed with surface water enabled plants to invade the land: the formation of cambium and secondary thickening made possible an enormous increase in size. But full luxuriance of growth is only possible with a more perfect system of water conduction than that possessed by the cone-bearers—the true vessels of the flowering plants have realised this possibility. And in the flowering plants the reproductive organs have achieved a complexity far in advance of that of any of their predecessors.

The Flower.—The pollen grains are formed in sporangia which we term pollen sacs, borne in pairs as the *anthers* of special organs called *stamens*, the small club-like bodies seen, for example, in the buttercup. The embryo sac is again formed in an ovule, but the ovule is completely enclosed by a special case—the *carpel*. Carpels and stamens occur typically together at the apex of a stalk which we call the *floral axis*. They are generally enclosed by one or two circles of leaf-like organs, protective in function and capable of rendering other services which we shall consider later. The whole constitutes a flower. The flower is a structure unknown among the cone-bearers. And further distinctions exist, of which the most noticeable that the ovules of the flowering plants are enclosed in a carpel (and the seeds formed from them in a seed-vessel), while in the cone-bearers the ovules are freely exposed. There is also a great difference in the development of the sexual generation: in the flowering plants it takes place after a plan which remains the same in almost all of the vast assembly of forms which makes up the class. We need not enter into details: sufficient to say that it is even further reduced than in the cone-bearers.

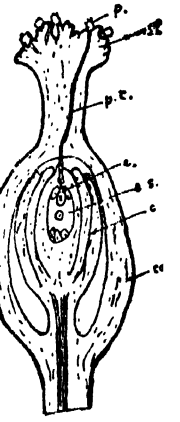

FIG. 13.—Section through Carpel.

ca., carpel wall; *c.*, coats of ovule; *e.s.*, embryo sac; *e.*, egg-cell; the other cells in the embryo sac are all that represent the female sexual plant; *st.*, stigma; *p.*, pollen grains; *p.t.*, pollen-tube making its way to the cell.

Flowers show an extraordinary variety in their construction. As an example of one which is supposed to be near the beginning of the ascent we may take the buttercup or crowfoot (*Ranunculus*). To the outside lies a circle of five green scales, the *sepals*, together composing the *calyx*. It protects the young flower in the bud. Next come five yellow *petals*, the *corolla*. Inside these are numerous stamens arranged in a spiral, and finally a crown of small green grains, the *carpels*, each containing a single ovule. In

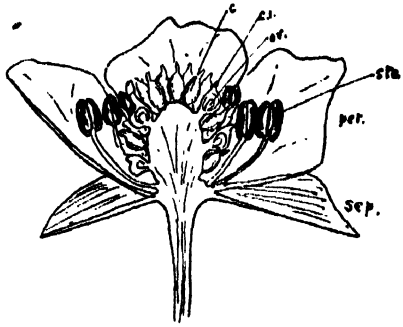

FIG. 14.—Section through Flower of Buttercup.

sep., sepals; *pet.*, petals; *sta.*, stamens; *c.*, carpel; *c.l.*, carpel cut open; *ov.*, ovule.

the case of such a flower the pollen is transferred to the carpels (on a receptive spot, the *stigma*, of which it germinates, sending a pollen-tube into the ovule) not by the wind, but by insects. At the base of each petal is a small scale which secretes nectar, and this is eagerly sought after by small insects. They are attracted to the flower by its bright colour, which acts as a guide. In crawling over the flower they rub against stamens and carpels, and transfer the pollen from the one to the other. This is a great economy for the flower. Pollen scattered by the wind must be produced in enormous quantities to ensure that one grain shall reach every ovule: millions of grains are wasted for every one that attains its end. When the process of *pollination* is carried on by insects, the waste, although still great, is much less. This is the main advantage secured by the possession of a "flower": and the advance in the structure of the flower has taken place along lines which lead to a greater nicety in the way in which the pollen is transferred.

Cross-pollination.—It has been found that a flower, the carpels of which have been provided with pollen from one of the same species, but growing on a separate plant (i.e. *cross-pollinated*) sets better and more abundant seed than one *self-pollinated*—with its own pollen. Now in a flower like the buttercup, which is open and shallow, the chances are that small insects crawling about the essential parts will procure self-pollination. We recognise as more advanced those flowers which have a structure preventing this, as in forms

where the nectar is concealed in such a way as to be accessible only to certain types of insects, and to these only when they enter the flower in a particular way. In the flowers of the pea family (sweet-peas, vetches, broom, whin, &c.) the stamens and the stigma are enclosed in a *keel* formed of the two lower petals. The nectar is placed at the bottom of a long tube formed by the stamens. Only a long-tongued insect can reach it, and to do so it must alight on the *wings* of the flower —the two side petals. Its pressure on these causes the keel to split open so that stamens and stigma strike the insect's body. The stigma does so first, and so has the chance of being covered with pollen from a flower formerly visited. The bee is the insect here concerned, and bees and moths are the most important agents in pollinating complex types of flower. Among other families which are remarkable for their ingenious mechanism for securing cross-pollination are the dead nettles (sages, mints, marjorams, woundwort, &c.), orchids and primroses. They are to be distinguished from flowers frequented by small insects and less specialised by the fact that the petals tend to be united to form a long, inaccessible tube, and to take on an asymmetrical form which requires the insect to visit them in a particular way.

It will be clear that the present beauty and complexity of floral structure has come about in connection with the relation of plants to insects, and that they are connected with two distinct aspects of that relation. The flower is of value to the insect chiefly because it offers a useful food—nectar; and pollen itself is also used as

FIG. 15.—Ox-eye.

food by bees. This supply is advertised by a flare of colour or a sweet scent. The mass of bright colour may be attained by making each flower large and gay; but it seems to be more economical to form crowded heads of smaller flowers—as in the members of the hemlock and daisy families. This latter is the largest and most abundant family of flowering plants, a fact which testifies to the success of its particular type of inflorescence—a compact head of small florets with the appearance of a single flower.

The complexity of the flower is due, on the other hand, to the desirability of securing cross-pollination by causing the insect's visit to take place in a particular way.

Devices against Self-pollination.—The same effect may, however, be attained in other ways. The stamens and carpels may be mature at different times. If, for example, all the pollen is shed before the carpels are ripe, then obviously self-pollination cannot take place. Sometimes if on the stigmas of a flower its own pollen and strange pollen are deposited at the same time, the strange pollen is favoured in some way that is not understood, so that it develops first and fertilises the ovules. Most efficient of all is the production of two different kinds of flowers on different plants. In the red campion flowers with stamens occur on one plant, flowers with carpels on another. Here, of course, only cross-pollination can take place. Such flowers are not to be regarded as primitive—*i.e.* as lying closer to the cone-bearers, where the ovules and stamens do not occur together. They are highly developed flowers, the ancestors of which have passed through a stage in which the flowers possessed both organs, and which at some later period have taken on the simpler form.

This remark applies also to the case of a fairly large number of flowering plants which have gone back to wind-pollination. The grasses, the sedges, the wood-rushes, and many of our trees are of this sort. Such flowers are usually inconspicuous—a bright corolla would serve no good purpose in attracting insects, it would rather protect the stamens from the wind which shakes out the pollen. Stamens and stigma are well exposed. Cross-pollination is secured by the ripening of stamens and carpels at different times. This may be seen beautifully in grasses and wood-rushes: if young flowers be examined it will be found that either the long stamens are dangling out, or the delicate stigmas are displayed, but not both together.

After pollination, fertilisation of the egg-cell in the ovule is carried out by the male cells in the pollen-tube. The direct consequence of this is the formation of an embryo either containing in itself a store of food, or associated with a separate store which arises in a peculiar manner from other cells of the reduced male and female plants. The embryo is enclosed in one or two seed coats and the whole forms the seed. At the same time the petals, sepals, and stamens most frequently wither and fall away, their work being done. All that remains of the flower are the carpels with the enclosed seeds. The carpels may be many and separate, each with one seed as in the buttercup: or they may be united

together to form a *seed-vessel*, inside which the seeds are arranged in a variety of ways.

While the seed is developing the seed-vessel also changes: it almost invariably increases greatly in size. When ripe it may have assumed one of two general types. It may be *dry*, in which case it splits open and so liberates the seed; or it may be *fleshy*. To this fleshy type we commonly apply the term *fruit;* but botanically *fruit* means the total result of the fertilisation of a flower, so that the dry *pod* of a broom or pea is no less a fruit than the *berry* of the tomato or currant.

Fruit.—The fleshy fruits are obviously likely to be eaten by various animals. This might appear to defeat the ends of the plant, but in reality it furthers them, for the seed is protected from the digestive juices of the animal's body by a very resistant covering. Only the fruit walls are digested, and the seed ultimately passes out in the excreta undamaged. Not only this, but it has been transported from the neighbourhood of the parent plant and deposited in a new situation and also in conditions favouring growth. This removal of the seed from the neighbourhood of the parent is of the greatest importance. Were all the seeds produced to lie about together, so great would be the crowding that many would perish. If means are taken to spread them far and wide they are much more likely to light in some unoccupied spot where there will be a better chance of successful development. Fleshy fruits are not alone in providing for seed dispersal. Many dry fruits possess devices which serve the same purpose. We may mention one or two. The fruits of many plants are provided with little hooks which fix in the wool of passing animals. They are thus carried about until they chance to be rubbed off, probably at a distant spot. *Burrs* are such fruits, and they belong to many different species —for example, the common goose-grass. The pods of the gorse and broom burst violently open when quite ripe and jerk their seeds far and wide; and this is a method adopted by many other plants. Very many fruits possess floats of some sort which enable them to remain suspended in the air while they are blown about by the wind—such are the thistles with little hairy tufts, or the various maples, the ash and the elms with different kinds of wings.

The Flowering Plants.—The evolution of the flowering plants has run along two main lines, and they are consequently divided into two subclasses. Almost certainly the older of them is the *Dicotyledon sub-class.* Its fundamental character is that the embryo possesses two *seed-leaves* or *cotyledons,* whereas the *Monocotyledons* have only one. This difference is associated with a number of others much more striking. In the former class the leaves tend to be broad with a network of irregularly branching veins. The flowers have their parts generally in fours or fives, and the larger members all have a cambium and secondary thickening. The monocotyledons have leaves which tend to be narrow, with regularly arranged parallel veins. The parts of the flower are in threes; and no cambium is present. They include the grasses (including cereals), the rushes, the palms, the orchids and all the great families of lilies, irises, and daffodils which are typically bulbous. They probably took their origin in some early stock of dicotyledonous nature. The dicotyledons include all our great forest trees and immense numbers of smaller plants, such as the families of the daisy, buttercup, primrose, pea, rose, hemlock and mint, to mention a few of the larger.

The flowering plants have arisen from an ancestor of the cone-bearing alliance. We have to-day one or two isolated types which are advances on the true cone-bearers, and others are known in the fossil state. The change took place by the enclosure of the ovule, and, as we have seen, in relation to the utilisation of the insects as pollen-carriers.

This is the highest stage reached in the vegetable kingdom. In it the adaptation of all organs of the plant to external and internal conditions has reached its greatest perfection. We have seen how vegetative organs are formed in response to two necessities—the maintenance of a proper supply of water, and the utilisation of a large quantity of sunlight. The reproductive organs are concerned with the bringing together of male and female cells, if possible of different parentage, with the proper protection and nutrition of the young embryo, and with the endeavour to give it a favourable position in which to start life. But one point of great interest must here be noted. In some of the most advanced of all flowering plants—for example, in the hawkweeds, which belong to the highest family of the dicotyledons—sexual reproduction has been abandoned, and with it the alternation of generations. The flowers appear perfectly normal, and pollen and embryo sac are formed as usual; but the egg cell develops without fertilisation, or the embryo sac may itself give rise to an embryo. In such cases it is found that in the formation of the embryo sac (megaspore) no reduction of the chromosomes occurs. We cannot say whether this is a mere abnormality cropping up here and there, or whether it represents the beginning of a new development in the reproduction of the higher plants. It is possible that the sexual reproduction may be entirely suppressed, and if only spore formation is retained then the plants adopting this type will set out on a path leading to an absolute change in the whole appearance and structure of the flower: the vegetation of the distant future will be as different from ours as ours is from that of the days when those plants were growing from which coal was made.

COURSE OF READING

We may approach the study of Botany from two different sides, with two distinct aims. Many people still look on it rather as the art of knowing the names of flowers than as the science of the life of plants. In other words, many do not desire to prosecute their study further than is necessary to teach them how to name wild flowers and perhaps to give them some account of their natural history.

To acquire a passable acquaintance even with our own flora, by no means an extensive one, requires a very considerable amount of study. This is evident when we note that on a moderate computation it includes about 1500 species. Many of these can be identified with considerable accuracy by using one of the numerous popular floras. Over 200 species are described and figured in the present writer's little book, *Wild Flowers* (The People's Books, Jack). Other popular floras are Hulme's *Familiar Wild Flowers*, 7 vols.; Step's *Wayside and Woodland Blossoms*, 2 vols.; Step's *Wild Flowers Month by Month*, 2 vols.; Anne Pratt's *Flowering Plants of Great Britain*, an ambitious 4 vol. work with 1500 coloured illustrations; Janet Harvey Kelman's *Flowers shown to the Children*; M. M. Rankin's *First Book of Wild Flowers*. These all possess coloured illustrations. Very good are Gowan's *Nature Books*, of which we may here mention the *Wild Flowers at Home* series, and *Our Trees and how to know Them*. These contain many excellent photographs.

These popular works usually make note of points of interest in the mode of life of the plants described, and refer to their uses or other relations to man. So their scope is wider than that of the flora in the strict sense which gives the name only with description sufficient for identification. But they labour under the disadvantage that they do not describe all the species; it is in fact impossible to do so without the use of exact scientific terms. This is unfortunate, for the rambler in the country very frequently chances on some species which from its rarity is omitted, or which so closely resembles other forms that it cannot be distinguished except by exact methods. The former case is especially true when the country explored has a flora more or less peculiar to itself. Thus the Cornish Peninsula, the West of Ireland, and the Scottish Highlands possess plants, occurring in these particular districts in abundance, but unknown over the rest of the kingdom, and they are consequently neglected in the shorter popular works.

Identification.—Anyone wishing to have at his disposal the means of identifying any plant he may find, can only do so by using one of the more complete floras and making himself acquainted with the terminology used therein. The best way to start is to read through some short account of the form of flowering plants. A little book by Sir J. D. Hooker, *Botany* (Macmillan), gives an excellent and sufficient account. Having done this, the actual naming of unknown plants should be attempted. The floras which may be used are Watt's *School Flora* (4*s*. 6*d*.); Hayward's *Botanist's Pocket Book* (4*s*. 6*d*.); Bentham and Hooker's *Handbook of the British Flora* (9*s*.); and Babington's *Manual of British Botany* (12*s*. 6*d*.). The first two are good but compressed accounts, Watt's book being illustrated. The two larger books, and especially Babington's *Manual*, are standard works. By far the best illustrations are the uncoloured woodcuts published under the title *Illustrations of British Flora*, by Smith and Fitch (9*s*.). John's *Flowers of the Field* is an illustrated flora which might be classed as semi-popular. In using any of these to determine the name of a plant the first thing is to find out the family to which it belongs. This is facilitated by the use of a "key." In the family the genus is discovered in the same way, and then the descriptions of the various species are read over till one is found which tallies with the specimen studied.

It will be found that the first dozen or twenty or even fifty plants will be difficult to determine, but after a time, as the terms become familiar and their value appreciated, the process becomes much easier. The only way to acquire facility is to work through a large number of plants.

One warning should be given. Several genera of British plants (the hawkweeds, the brambles, the roses, the willows) are split up by specialists into a large number of species which differ only slightly from each other. It is impossible for anyone but a specialist to distinguish the majority of these. The beginner will also find that the grasses and sedges are difficult plants to identify, but they may be conquered with patience.

A useful work to have is the *London Catalogue of British Plants* (9*d*.), a list of all species recognised as British, with the number of counties in which each occurs noted.

Natural History.—No one will be likely to rest content with merely naming wild flowers; for in doing so it will be found that an introduction has been obtained to various other fields. For example, it is interesting to try and frame a list of the plants found in the district in which one is collecting,[1] and still more interesting to note the way in which they are distributed in the area. It will soon become evident that the flowers of the fields are not the flowers of the ditches, and that both differ from the species to be found in the woods or moors. In other words, plants grow in definite communities which

[1] In a district within easy walking distance of one centre, it is always possible to count on finding 200 to 400 species of flowering plants.

occupy stations equally definite in character. Then again the natural history of the plants found will engage attention. The methods of pollination, the methods of seed dispersal, the methods of support are of infinite variety. Special reference will be made to works on these subjects: here it is merely intended to point out the way in which a knowledge of the names of plants opens out new prospects of nature study.

Of other plants which lend themselves to collecting, the chief are the lichens, the toadstools, the mosses and the seaweeds. But none of them are of great general interest. They do not possess such diversity of adaptation as the flowering plants. They can only be determined satisfactorily by using standard technical works: Massee's *British Fungi and Lichens*, McVicar's *Student's Handbook of British Hepatics* (Liverworts), Dixon and Jamieson's *Student's Handbook of British Mosses*, Mrs. Gatty's *British Seaweeds*. A popular collection of photographs of toadstools is *Toadstools at Home* (Gowan's *Nature Books*).

The Real Study of Botany.—The other view which we may take of Botany is that it is the science of the life of the plant. To obtain a knowledge of how the plant lives in the widest sense of that term involves study of a much more fundamental character: it is necessary to begin at the beginning, and go into each successive aspect of plant-life which presents itself—structure and its relation to function, general physiology, classification, the relations of plants both past and present to each other, and the light this throws on lines of descent: ecology, the study of the plant in its inter-actions with other plants, with animals, and with inanimate nature. The literature of the subject is immense: no professional botanist is acquainted with a tithe of it; but it is possible to select a few books the mastery of which will result in a very fair insight into the nature of the plant's activities.

One point must be emphatically stated: reading without some observation is of little use. A great deal may be done with no apparatus. A microscope is most desirable: even the use of one for an hour or two enables the student to get an invaluable idea of the real size and shape of a cell. It is difficult to appreciate the nature of a structure so much outside the run of everyday experience as the cell, unless it can actually be seen. Still much can be learned with no instruments more elaborate than a pocket knife, a couple of needles mounted in wooden handles, and a lens. Such a master of minute scientific observation as Charles Darwin scarcely used more.

Anyone wishing to make a start in the study of botany cannot do better than work through Dr. Frank Cavers' excellent elementary book, *Plant Biology*, which gives directions for simple observations and experiments. A somewhat more complete survey of botany is given in Fritsch and Salisbury's *An Introduction to the Study of Plants*, which is well illustrated and gives directions for practical work. Groom's *Elementary Botany* is useful, but confines itself to the higher plants. Oliver and Grove's *Elementary Botany* and Oliver's *Systematic Botany* form together a good introduction, but they are of the nature of "cram" books, and do not give practical instructions. After mastering one of these, and having paid as much attention to the practical side as is possible, a general foundation will have been laid, and time may be profitably devoted to the particular questions of most interest to the student.

There are several textbooks which might be used at this stage and which give a very full account of all the classes of plants, along with discussions of their general behaviour—physiology, ecology, &c. The best of all these is Strasburger's *Textbook of Botany*, an exhaustive and authoritative work by four German botanists. It is regularly brought up to date and revised. English editions are issued every few years, the latest being dated 1912. It is profusely illustrated, and gives numerous references to special literature on particular subjects. It is not an easy book to read, the information is so concentrated and full: it is a work for careful study. An American book, *The Chicago Textbook of Botany* by Coulter, Barnes and Cowles, is another excellent treatment of the whole field of botany; it is much more easily read than the German work. The first volume deals with morphology and physiology: the second on ecology is very interesting, as it treats of the plant in all its relations to the external world. Scott's *Structural Botany* gives an account of the structure and life-history of types of all the great groups of plants. One volume deals with flowering plants, a second with the lower orders.

Fossil Plants.—On the structure and relationship of fossil plants several special works exist. The best is the large two-volume *Studies in Fossil Botany* by D. H. Scott. A brief account by the same author entitled *The Evolution of Plants* is a splendid introduction: while here may be mentioned Marie C. Stope's *Ancient Plants* and Seward's *Links with the Past in the Plant World*. A book of photographs is published in Gowan's series—*Fossil Plants*.

Seed Plants.—On the life-history and structure of the seed plants Coulter and Chamberlain's *Morphology of the Gymnosperms* (cone-bearers) and *Morphology of the Angiosperms* (flowering plants) are the best books. While on the fern allies an original work of the greatest general interest is F. O. Bower's *The Origin of a Land Flora*, in which the author traces in a masterly way the lines along which the evolution of the higher plants has run.

Structure of Flowering Plants.—The structure

of the flowering plants is treated in a general way in several of these treatises. Others exist which pay more special attention to it. Anatomy has recently been linked up with physiology: formerly it was regarded as a branch of botany sharply separated from the rest of the subject. Chiefly owing to the researches and writings of George Haberlandt this has been changed, and we are now accustomed to look at plant structure with thoughts of how the various organs work in our heads. The most important work on anatomy from this point of view is Haberlandt's *Plant Anatomy on a Physiological Basis*, of which a translation by Drummond has recently (1914) appeared. A very good shorter work on similar lines, which has the advantage that it gives directions for practical study, is Steven's *Plant Anatomy*. Farmer's *Plant Life* is a short account of "plant form from the point of view of function."

Species and their Inter-relation.—The systematic study of the flowering plants, that is the description of species and of their inter-relation, is a subject which does not lend itself to general treatment. A good condensed account is given in Strasburger, and in the elementary books by Groom, and Fritsch and Salisbury. Willis's *Flowering Plants and Ferns* is quite invaluable. It is arranged as a dictionary which deals with all the families and important genera of these groups. It gives descriptions, discusses systematic position, and makes notes on natural history and economic use. For anyone with botanical leanings the book is most strongly to be recommended. In it we find details of plants come across in random reading. Or it may be taken in the pocket on visits to botanical gardens or museums or new countries. For the rest recourse must be had to the special floras of particular countries—works which to say the least are not suitable for light reading.

Lower Orders.—The books on the lower orders are mainly descriptive and systematic. These plants can only be studied with the microscope, and unless it is proposed to use that instrument the articles in the general textbooks mentioned are all that can be assimilated with profit. If a microscope is available, however, the collection of algæ and microscopic fungi is very interesting. Examination of the green slime of ditches, the mud of ponds, the drainings of the stems of water plants, and scrapings from trees and moist stones or bricks, yield numbers of exceedingly beautiful microscopic forms of algæ. These may best be identified by West's *British Fresh Water Algæ*, a work unfortunately out of print, but which one hopes will be reissued shortly. The microscopic fungi of most interest are those, such as the rusts, smuts, and mildews, which cause disease in higher plants. Marshal Ward's *Disease in Plants* is a general treatment of the subject. Massee's *Diseases of Cultivated Plants and Trees* is perhaps the most useful detailed account. A small, more popular, but very good book is Erikson's *Plant Diseases*. On bacteria, apart from the general textbooks, Fischer's *Structure and Functions of the Bacteria* (trans. by Jones) may be consulted, but it is somewhat out of date, and is highly technical in character. It is unfortunate that no book exists in English which gives an account of those bacteria and fungi which are of interest economically—*e.g.* the various bacteria which convert substances in the soil, or the yeasts. Practical work with bacteria, while of the greatest interest, can only be carried on in a properly equipped laboratory.

Plant Physiology.—The more general aspects of botanical science are dealt with almost wholly in connection with the life of the seed-bearing plants. The fundamental branch is *physiology*, which has received a great deal of attention, and to which are devoted many books, popular and scientific. The elementary books and the textbooks mentioned discuss physiology. Of books devoted specially to it the best in English are Macdougal's *Textbook of Plant Physiology*, and Reynold Green's *Vegetable Physiology*, and an excellent smaller work by Duggar, *Plant Physiology*, which takes the subject from the agricultural side. Translations of the two standard works on the subject, Jost's *Lectures on Plant Physiology*, and Pfeffer's *Physiology of Plants*, are also available. We are fortunate in having on the practical side one book of outstanding merit from the point of view of the student without apparatus. Osterhout's *Experiments with Plants* teaches how a great many experiments, illustrating the most varied aspects of plant activity, may be performed with materials to be found in any house. It may be recommended most strongly. Keeble and Rayner's *Practical Plant Physiology* may also be recommended. Darwin and Acton's *Physiology of Plants* and Detmer and Moore's *Practical Plant Physiology* are more technical in character.

Czápek's *Chemical Phenomena of Life*, and Benjamin Moore's *Nature and Origin of Life*, treat generally the phenomena associated with living organisms. Timiriaseff's *Life of the Plant* is a popular account of physiology. Regions of plant physiology which are of special interest are the studies of movements and of insectivorous plants. No recent English work has appeared on them. The classical memoirs are Darwin's *Insectivorous Plants* and *Movements and Habits of Climbing Plants*. Chapters are devoted to these in Geddes' *Chapters in Modern Botany*, and they are of course dealt with in the general works already mentioned. Verwrón's *General Physiology* is a noteworthy attempt to unite the physiology of plants and animals into one science.

The relation of plants to the external world is variously termed *biology*, *natural history*, and *ecology*. The last-mentioned term tends to be used to denote the relation to inanimate nature,

the two first are more used in connection with living organisms.

The soil in its relation to plant growth has recently been made the subject of expert exposition in three books by E. S. Russell: two of these are elementary and popular—*Lessons on the Soil* and *The Fertility of the Soil;* the third, *Soil Conditions and Plant Growth*, reviews the modern scientific study of the soil and gives an exhaustive bibliography.

Plant Communities.—This brings us to the study of plant communities. It has already been mentioned that plants do not occur at random in any situation, but that they are associated together in definite groups. The particular type of vegetation occurring in any given station is determined by the climate and the nature of the soil; and it is a fascinating study, to which much attention has been paid in recent years, to work out the relation between plant communities and the stations in which they occur. The book which is at present to be regarded as the standard is Warming's *Plant Œcology.*[1] More general in nature are Clement's *Plant Physiology and Ecology* and the second volume of *The Chicago Textbook.* Chapters in an excellent little book of Bower's, *Plant Life on Land*, also deal with plant communities. A more detailed stage of this study is reached when we work out more or less exactly the way in which types of vegetation are distributed over the face of the earth, or over smaller geographical areas. Here again we have an exhaustive memoir, Schimper's *Plant Geography on a Physiological Basis*, and reference should be made to Miss Newbiggin's *Modern Geography.* Recently a group of British botanists has issued, under the editorship of A. G. Tansley, a volume of studies entitled *Types of British Vegetation.* In it we find descriptions of the vegetation of different regions of our country, with discussions of the relation of each type to soil, &c. An attempt is made to trace the development of the various communities, and the work is profusely illustrated with excellent photographs. C. E. Moss' *Vegetation of the Peak District* treats a small region exhaustively from the same standpoint.

The general biology of plants is the subject of the great work of Anton von Kerner, *The Natural History of Plants.* The four volumes with their numerous illustrations furnish detailed information on innumerable points of interest in the life of the plant, and may be read with the greatest pleasure as well as profit. On pollination we have a splendid book in Müller's *Fertilisation of Flowers*, and shorter accounts in Lord Avebury's (Lubbock) *Flowers, Fruits and Leaves*, and Korner's *Flowers and their Unbidden Guests.* Three memoirs of Charles Darwin, *Contrivances by which Orchids are Fertilised, Cross and Self-fertilisation*, and *Different forms of Flowers on Plants of the same Species*, are original contributions to this subject.

Heredity.—Heredity and evolution rather come under the heading of General Biology, but much of the work on these problems has been carried out with plants. There is a large number of books on heredity. Examples of the most satisfactory are *Heredity*, J. A. S. Watson, the large work of Prof. J. A. Thomson, *Heredity*, Bateson's *Mendel's Principles of Heredity*, and Punnett's *Mendelism.* On evolution we have Profs. Thomson and Geddes' *Evolution*, and *Evolution* by E. S. Goodrich. The original works of most general interest are Charles Darwin's *Origin of Species* and *Descent of Man*, De Vries's *Species and Varieties* and *The Mutation Theory*, Samuel Butler's *Evolution Old and New*, Bergson's *Creative Evolution*, and Bateson's *Problems of Genetics.* The study of evolution has found a practical application in the endeavour to produce new varieties of plants. The successes which have met this line of study are detailed in delightful fashion by De Vries in *Plant Breeding*, while Newman's *Plant Breeding in Scandinavia* is a valuable work.

On the history of botany Sach's *History of Botany* is a classic which deals with the period up to 1800, while a continuation by Reynolds Green carries the story to 1900.

Of course the books mentioned are only a very small fraction of the total literature of botany—even if we exclude original memoirs. That this is so illustrates sufficiently the vastness of the subject. Enough are noted to give an introduction to most branches of the science, and information on more special literature is always to be found in one or other of the more general works.

Many of these books are beyond the means of the ordinary reader. Scientific works are expensive, but judicious selection and access to a good library will usually enable the student to obtain sufficient literature to satisfy his needs.

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[1] Œcology = Ecology.

ZOOLOGY

Introduction.—Zoology (Gr. *zoon*, an animal; *logos*, science, account) is the science which deals with animals, their structures and habits, and their relationships to animate and inanimate nature. To many the science appeals simply as a hobby, which from the added interest it gives to life repays the close and constant observation it demands. But there are aspects of the study of animals of more import to mankind. The knowledge of the functioning of animal organs helps the physician to understand the workings of man's body. Researches into the structure and habits of the harmful parasites of man and of his domestic stock, and of the many destructive creatures which do damage to his crops or possessions, lead towards a knowledge which will enable man to cope with the pests, by reducing chances of infection, by checking their ravages, or by utterly destroying them. A less negative good is accomplished by such a study as that of the habits of fishes, whereby artificial culture, transplantation, and other means may be devised to ensure a constant or an increasing supply of a valuable food material.

Naturally Zoology, however distinct it may seem at first glance, does not stand alone amongst the sciences. It is linked to most by ties more or less close: for example, with Botany it is closely united in the comprehensive science of life—Biology; Geology aids it in the unravelling of the succession of past life; Chemistry explains the nature of the materials of living things and the workings of many organic processes; Physics the inner secrets of the moulding of form and the values of many types of structure; and so on. By many the two last sciences are held to be capable of explaining the whole mystery of Life.

Historical Sketch.—The study of animals must have been one of the earliest exercises of man's developing brain, for the necessity of obtaining food must have driven him to observe with intent the habits of deer or of wild ox, or of his smaller prey. That his observation of habits and structure was both acute and accurate is amply demonstrated by the still existing pictures with which prehistoric (palæolithic) man decorated his cave dwellings; and by such wonderful incised carvings as those which beautify many antlers and bones found in the French caves of Vasère and Dordogne. On these, fishes, birds, horses, and deer riot in an artist's jumble of sketches, or are sorted into little pictures which illustrate at one time the drinking habit of a deer, at another the close array of a galloping troop of wild horses. The mammoth himself is faithfully represented on the ivory of one of his own kind. This first period, of random and haphazard observation, continued for long ages, until it merged finally in the classical period, when for the first time animals began to be studied for their own sake. One of the early and the greatest of the representatives of this age of systematic zoology was Aristotle (384–322 B.C.), the "father of natural history," who during a residence on the Ægean seaboard, made close and telling observations to such purpose that some 500 animals were catalogued and described by him with marvellous accuracy. Another great but less worthy zoologist may be taken as shadowing the end of the classical period—Pliny the Elder (A.D. 23–79), who, in his *Historia Naturalis*, collected with an utter lack of discrimination all manner of current animal lore.

Following the Classical Period came a period of decline—the Legendary Period—when any absurd scrap of folk-lore, or impossible traveller's tale, was branded as zoological truth. The result was the building up of a history of nature wherein fact and fancy were inextricably jumbled. Such was exhibited in the widely circulated volumes of allegorical stories known as *Bestiaries*, or in the more or less symbolical figures of animals sculptured by the early Christians on standing stones scattered throughout the north-east of Scotland.

Not till the Renaissance and the revival of the old desire for knowledge, in which all science shared in the fifteenth century, was any steady advance made in Zoology. But then, in the gradual sifting out of the standard fables, and in the earnest endeavour at fresh and first-hand investigation of nature, were laid the foundations of modern zoology. Each century added to the roll of earnest and effective workers. In the sixteenth the Englishman Wotton (1492–1555), the Swiss Gesner (1516–1565), and the Italian Aldrovandi (1522–1607), prepared the way for the great zoologists of the seventeenth and eighteenth centuries—Harvey (1578–1657), Linnæus (1707–1778), Buffon (1707–1788), Lamarck (1744–1829), Cuvier (1769–1832), St. Hilaire (1772–1844), and in the early nineteenth von Baer (1792–

1876) and Owen (1804–1892). So we are led to Darwin (1809–1882) and the recent developments of zoological science.

Nothing is more characteristic of present-day zoology than the fact of specialisation. So successful has the search after knowledge been that the facts have become too many for the grasp of any single brain, and accordingly the science has split into well-defined branches, each dealing with a particular aspect of animal life. Thus the structures of animals are dealt with by *Morphology* if the crude structures, the general form of the animal, be the things considered; by *Histology* if the cell tissues be in question; the functions of animals constitute the realm of *Animal Physiology;* their early development of *Embryology;* their fossilised remains of *Palæontology*, or more strictly *Palæozoology;* their habits of *Bionomics;* their life relationships to their neighbours, and to their inanimate environment, of *Ecology;* their relationships to man and man's affairs of *Economic Zoology;* while *Systematics* in its endeavour to classify all animals in natural groups takes cognisance mainly of the facts gained through embryological and morphological studies. None of these branches, however, can stand by itself alone. There is a constant interchange of information from one to the other, and all aid in the building up of the great generalisations of zoological science which are sometimes grouped under the title of "philosophic zoology."

These branches of Zoology shall be the subject of after treatment; but in spite of the complicated nature of the final result of specialisation it clears the air to remember that the process has followed a natural evolution in which the studies of structure and of function have kept a parallel march. Crude form was first investigated, and with it life habits; then came the closer investigation of organs, and of their function, to be supplemented later by the detailed examination of their tissues, and of the properties of these. The microscope revealed cells as the basis of tissues, and the examination of cell-activities followed; and lastly the material of the cell itself, and, associated therewith, the inherent properties of change, or the metabolism of protoplasm, became the centres of attention.

THE FUNCTIONS AND STRUCTURES OF ANIMALS

In our historical sketch we have noted that the general forms and structures of animals were first studied, the investigation of the workings of the parts following closely thereafter. Herein we see a sequence similar to that of the child's questions: "What is it? Why is it? How does it work?" But the logical arrangement is the reverse, for the functions of a body are more vital than its parts. In a dead animal the structures may be perfectly preserved notwithstanding that the functions—the essence of life—have ceased to exist. Moreover, to the development and specialisation of function are due in great part the external and internal forms of animals. We shall therefore gain a more intelligible notion of the increasing complexities of animal life if we commence with a study of the essential workings of living creatures, and trace their gradual development in relation to more and more complex organs.

Living and Not-living.—Everyone distinguishes in a rough way a living thing from a lifeless. No one is likely to confuse an inert statue with the active creature it represents. Yet sometimes the distinction is hard to tell. Most of us would regard a turtle, the head of which has been cut off, as a dead turtle. Nevertheless the heart has been taken from a decapitated turtle, moistened with salt solution and suspended in a humid room, and so it has continued to beat for days. The animal was dead, and yet its tissues remained alive. Similar experiments have been carried out on other creatures, with similar results. No matter how closely the living tissues are examined, it is impossible to say exactly what the life in them is; but the life is expressed in certain definite functions, and these functions are peculiar to a highly complex life-stuff, protoplasm—"the physical basis of life."

Living Matter.—The seat of life, protoplasm, has been investigated by chemists with the greatest minuteness in the vain hope that the discovery of its physical and chemical constituents might solve the riddle of life. It is exceedingly complex in nature, but it has no definite make up. In the main it is built of atoms of carbon, hydrogen, oxygen, and nitrogen; in lesser amount it contains sulphur and phosphorus, and it may possess traces of one or several of potassium, sodium, magnesium, chlorine, calcium, iron, zinc, manganese, and iodine. Protoplasm is indeed a collection of chemical mixtures and no true chemical compound; but though its composition may vary, by its properties it is known.

Functions of Living Matter.—In living matter at its simplest the essential functions of animal protoplasm are most easily deciphered. *Amœba*—one of the Protozoa—is the simplest type of animal known. It consists of a tiny globule of jelly, about $\frac{1}{100}$th of an inch in diameter, in which the microscope reveals fine granules, transparent spots or vacuoles, and a complicated kernel or nucleus. There are no head, eyes, food canal, brain, or any organ as one thinks of organs among the higher animals. Amœba is simply a single cell, and yet it presents in miniature, as it were, the whole gamut of animal functions. As one watches, a part of its body appears to flow out in finger-like processes (*pseudopodia*, or false feet), and the mass of

the body flows after them. So Amœba changes position—it has the power of locomotion. But it has no definite limbs, any part of the body may become a *pseudopod;* the power which causes the motion is diffuse. The movement is essentially due to the contraction of the pro-

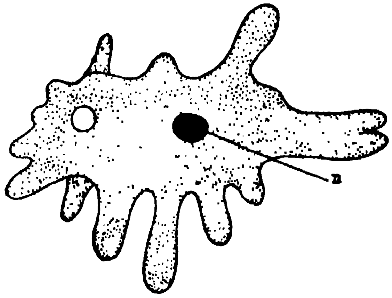


FIG. 1.—An Amœba progressing. Highly magnified. The direction of movement is towards the right; *n*, the nucleus.

toplasm, and this function of *contractility* is equally present in all parts of Amœba's body.

Amœba can move, and move in any direction on a plane surface, but the movement is not irresponsible. Place near it a harmful substance, say a drop of weak acid, and the protozoon will retreat; whereas it will advance towards a desirable object, such as a food-particle. It responds to changes in its surroundings, and therein exhibits a second characteristic function—that usually termed *irritability*.

Should Amœba sense a food-particle, a diatom, or bacterium, it moves towards it, flows round it, and the food becomes engulfed in its body together with a drop of the water in which it lies. Within the body the substances useful for nourishment are dissolved by secretions and built into the general protoplasm; that is to say, Amœba possesses the power of *digestion*, a manifestation of the wider function of *secretion*. The dissolved substances are absorbed into the cell material—the function of *assimilation*—but the indigestible portions, such as the flinty shells of the diatom, are cast out of the body—a process known as *excretion*.

Lastly Amœba, having grown to the limit of its size, may split gradually into two half-cells, each of which becomes free and is itself a complete but small Amœba. This process, which is preceded by complex but orderly changes in the kernel or nucleus, exemplifies the function of *reproduction*.

These five primitive functions—contractility, irritability, secretion, assimilation, and reproduction—are characteristic of the simplest animals, but these are present in a diffuse, unlocalised way. To their gradual specialisation and growth in efficiency are due the essential structures of all higher animals, as the following paragraphs endeavour to outline.

The Development of Function and Structure

The Differentiation of Contractility—Muscles.—Although in Amœba the power of contractility is everywhere diffused and everywhere equal, in some of Amœba's relatives amongst the Protozoa the condition is by no means so simple and primitive. The Slipper Animalcule, *Paramecium*, swims in water with a boring motion—a mode of progression due to a coat of exceedingly fine hairs or cilia which covers its body. The cilia project from the surface and move rhythmically so that the minute creature is wafted through the water. Contractility is here no longer diffuse and equally distributed: it is concentrated in the cilia, which have become the sole agents in locomotion. Here, in a single-celled animal, a portion or portions of the cell become told off as specialists in the function of contractility, and two results of the specialisation are evident: first, that since the cilia alone can control the movements of the creature other portions of the body are relieved from the duty of contributing to locomotion, and so have better opportunity for specialisation in other functions; second, that specialist cells or portions of cells, the duties of which are confined to locomotion, become more efficient locomotor organs than cells which have to distribute their energies over many functions. These two advantages are the common gain of organisms wherein functions become individualised or differentiated, and cells or tissues become specialised for the performance of one function only.

In some single-celled animals contractility has become differentiated to a very high degree. In the Bell Animalcule (*Vorticella*), for instance, the main "body" of the creature is perched upon a long, straight stalk, which, when stimulated, coils like a spiral spring, dragging the body away from the irritating factor. This extraordinary contractility resides in a thread of protoplasm within the stalk, and one is justified in looking upon this thread as a portion of the cell specialised as a muscle fibril. In most many-celled animals the specialisation

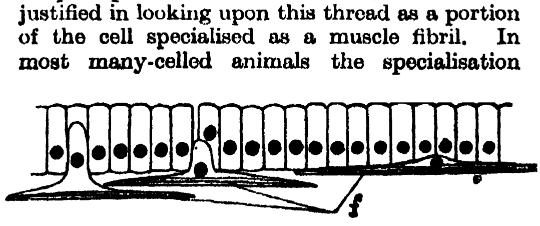


FIG. 2.—Diagram showing gradual change of Epithelial Cells into Muscle Cells. Highly magnified.

f, the basal tails of the cells in which contractile fibrils appear.

is carried still further. The simplest and most generalised type of cell in these more complex organisms is of a regular columnar form, many lying together in a single layer or pavement (an "epithelial" layer—Gr. *epi*, upon; *thelion*, a tile), the surface of which appears more or

less like the surface of a honeycomb. From such simple cells various special cells have been developed.

Complete cells are set aside to perform practically no other function than that of contraction, and these long spindle-shaped cells are called "muscle cells." These are grouped to form muscle tissues, which may perform slow, rhythmical ("involuntary") contractions, as in the walls of the stomach and intestines, and are then composed of unstriped muscle fibres; or they

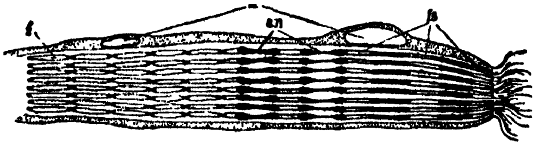


FIG. 3.—Part of a Cross-striped Muscle Fibre. Highly magnified.

an, anisotropic substance; *is*, isotropic substance in a single fibril; *f*, a fibril; *n*, nuclei.

may perform active ("voluntary") contractions, and are then formed of striped cells which are aggregated into organs known as "muscles." The muscles of a whole creature are unified in a muscle "system."

This short sketch indicates that the development of contractility has followed the lines of the greater and greater individualisation or differentiation of the function; and that, associated with the advance of the function, has been a parallel structural differentiation. At first there were set apart for contractile purposes no particular structures, then portions of a single cell took up the function, and still later complete cells which in increasing complexity are combined into tissues, organs, and systems. And with each increase in specialisation the working of the function becomes more perfect.

Similar developments occur in each of the five functions which, in their simplest state, we have described in Amœba. It will be sufficient as regards the others merely to indicate their connection with the structures which their gradual specialisation has evolved.

The Differentiation of Irritability—the Nervous System.—In Amœba the function of irritability is diffuse—no special portion of the cell is specially sensitive to external influences—but even in some of the most primitive many-celled animals there occur special *sense* cells distributed in the outer layer of simple, elementary epithelial cells. These are furnished with *sense hairs* which transmit impressions from the external environment. Gradually in the course of development some of these simple sense cells give up their general function as protecting epithelial cells and sinking in from the surface become more and more specialised until they become sense cells and nothing more. The characteristic structure of such a cell—a *nerve cell* or *neuron*—is a thread-like fibre

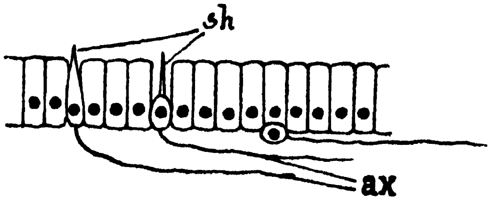


FIG. 4.—Diagram showing gradual change of an Epithelial Cell into a Nerve Cell. Highly magnified.

ax, axons; *sh*, sense-hairs of incipient nerve cell.

ending in fine tufts of fibrils or *dendrites*, the latter ultimately in touch at one end of the main fibre with external sense cells, and at the other with a muscle or gland cell. The fibrils at the sense-cell end receive impressions from without, which are transmitted with extraordinary rapidity along the main fibre or *axon*, and are distributed by the other fibrils to the muscle or gland cell with which they are in contact. So a muscle cell receives, by way of a nerve cell, impressions which may have originated far from its actual station, and as the impressions foretell benefit or harm to the

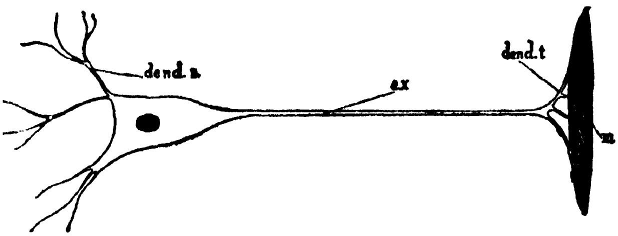


FIG. 5—Diagrammatic Figure of a Neuron or Nerve Cell in connection with a Simple Muscle Cell. Highly magnified.

ax, anon; *dend. r*, receptive dendrites; *dend. t*, terminal dendrites; *m*, muscle cell.

creature concerned, the muscles cause the organism to approach or withdraw from their source. Thus the effectiveness of the function of irritability is increased. Finally, it reaches its highest degree of specialisation with the combination of many nerve cells in a nervous tissue, containing nerve fibres arranged parallelwise in a bundle or *nerve*, and bodies of cells united in knots or *ganglia*; and further, with the combination of such tissues into a unified nervous system. The main value of a nervous system lies in this—that in a many-celled animal, where of necessity many parts are situated far from contact with the exterior, the nervous system receives the impressions of sense from the outer world, and transmits

them to those internal parts which are concerned with the message.

Many are the specialised types of nervous system, from the small-brain systems of the lower invertebrates with their widely-scattered nervous centres to the highly organised and centralised big-brain systems of the higher animals and of man, but this common feature may be noted—that since feeding is the primary "chief end" of an organism, the main nervous centres tend to lie near the mouth, and accompanying them there are usually to be found the main sense-organs—of sight, hearing, and touch—which they render effective in the search for food.

The Differentiation of Secretion and Assimilation.—In Amœba, secretion and assimilation, we saw, were limited to digestion and the absorption of the products of digestion, and were functions common to the whole cell. But even in Amœba's fellows, such as the Foraminifera, a second development of the secretory function is exhibited, for not only do they secrete in their internal parts juices which digest food, but the external parts secrete a solid protecting shell of lime. These processes foreshadow two main developments—the differentiation of the digestive system, and the differentiation of solid protecting and supporting secretions—scales, hair, nails, bone, and such like. In many-celled animals, special cells—gland cells—take up the work of secretion, and as the scale of life is ascended, become grouped in ever-increasing complexity. To illustrate by

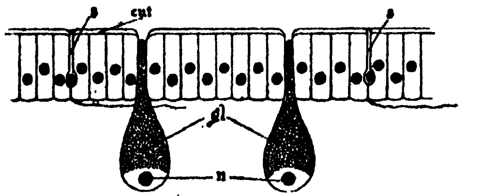


FIG. 6.—Diagrammatic Representation of Simple Columnar Epithelium containing Gland Cells and Sense Cells.

cut, cuticle; *gl*, gland cell; *n*, nuclei; *s*, sense cell. Highly magnified.

three progressive stages. The *glandular cells* which subserve digestion and which are closely associated with the absorbing assimilating cells are arranged in *Hydra*—a primitive Cœlenterate—as the lining of a simple sac; but in the earthworm they line an elongated tube—the *intestine*—and their number and total efficiency are increased by a large surface-multiplying fold of the intestinal walls—the *typhlosole.* Not only so, but there are also accessory secretory organs—three pairs of *œsophageal glands*, the juices of which flow into the food canal and help to prepare the food for absorption. Amongst mammals, however, the division of labour is carried much further. The intestine is still of chief importance, but it is supplemented by many glands: the *salivary glands* with their ptyalin converting starch into sugar, the *gastric juice* of the stomach with its pepsin turning proteids or albumens into peptones, the *pancreas* whose trypsin continues the work of the salivary and gastric juices and breaks up fats, and the *liver* with its bile.

It must be remembered that here is indicated the differentiation of only one type of secretory glands—those concerned with digestion. Many other kinds of glandular cells are developed, especially in the higher animals, such as *sebaceous glands, sweat glands*, and the *lacteal glands* which become highly developed and aggregated in mammæ. The function of secretion is also responsible for the formation of hair, bristles, scales, nails, cartilage, and bone.

Absorption and assimilation of the dissolved food-stuffs is closely connected with digestion. In Amœba the cell which digests also absorbs, but in many-celled animals where the function of digestion is localised, means have to be devised whereby the digested materials can be carried away to nourish the cells in every part of the body. The *blood-stream* and the *lymph-vessels* are the carriers, dissolved foods (except the fats) passing directly into them, to be borne to the liver which acts as a food regulator, and thence throughout the body. But another type of assimilation is also developed, that whereby the blood, spread out in fine vessels on skin, gills, or lungs, seizes upon the oxygen of air or water and passes it to the tissues through the medium of the lymph.

Co-ordinated with assimilation of useful products is the discharge of waste products, or excretion. This in the simplest animals is a direct ejection of insoluble matter which has been engulfed, but in higher animals it means not only the ejection of solid insoluble matter, but, further, the withdrawal from the blood of many waste materials it carries—such as carbon dioxide, the nitrogen products of digestion, and any abnormal content. These are removed by the *kidneys.*

The Differentiation of Reproduction.—Amœba again, on account of its simplicity, forms the point from which we start. Here reproduction was merely the rupture of a fully-grown cell into halves each of which became a perfect individual. Such a type of reproduction is common in Protozoa, although even amongst some of these, such as the Slipper Animalcule (*Paramecium*), there is a close contact between adult individuals and a complicated interchange of cell matter, before the individuals separate again, rejuvenated. Or again unfavourable conditions may cause the formation of a "resting-stage," a hard-walled cyst, wherein develop many minute *spores* each of which becomes an adult Protozoon. In many-celled animals, as one would expect, the specialisation of reproduction is carried to greater

lengths. In the lower forms sets of cells from almost any part of the body can produce new individuals. Simple buds grow out from the parent, and these may break away to form new, free persons, as in Sponges or *Hydra*, or may remain attached, to bud again in their turn, so that, as in many Hydroid Zoophytes and Corals, aggregations of individuals or "colonies" are created. Sometimes a Sea Anemone may simply split into two, each half becoming a perfect adult. On account of their resemblance to the budding of plants such methods are known as *vegetative* or *asexual reproduction*. But in the higher animals a more complicated system of *sexual reproduction* has evolved, its essence being that certain cells in the body are set aside from the first for the purpose of renewing the race. The sexual cells are of two kinds, ovum or egg and spermatozoon, and may occur both in one animal (*hermaphroditism*), or more usually in different individuals known as female and male. Normally a new individual can arise only from the union of a sperm with an ovum, which is thus stimulated into growth; but in exceptional cases (amongst Green Flies, Brine Shrimps, Stick Insects, and so on) the egg may develop without fertilisation for generation after generation—a phenomenon known as *parthenogenesis*. Great and increasing specialisation is also noticeable in the more and more perfect methods by which, with the least possible waste of material, fertilisation is accomplished.

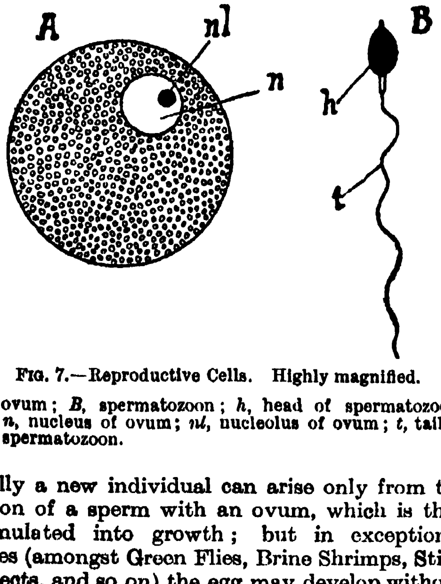


FIG. 7.—Reproductive Cells. Highly magnified.

A, ovum; *B*, spermatozoon; *h*, head of spermatozoon; *n*, nucleus of ovum; *nl*, nucleolus of ovum; *t*, tail of spermatozoon.

At the conclusion of this summary consideration of the complexities which grow out of the five simple functions of Amœba it would be well to view the subject for a moment from a general point of view.

The functions of all higher animals, so far as we can see, are simply developments of the life-processes exhibited in the simplest known animal. Division of labour takes place amongst cells once equal and similar, some becoming more expert at performing one function, some another. And alongside of specialisation of function develops specialisation of structure. This specialisation in great part gives us the clue to the relative positions of animals in the scale of life—the higher creature being the more specialised, the lower the less specialised or more generalised. The gain derived from increased specialisation is a greater perfection in the performance of a function, but against this must be set the fact that the more specialised a cell or organ may be the less is it able to perform any but its own function; so that its ultimate value depends on the perfection of its association or *correlation* with other specialised cells or organs.

On the differentiation of organs, influenced by the animate and inanimate environment of an animal, depends its *form* or *symmetry*. The simplest and most primitive symmetry is that exhibited by simple sponges and many Cœlenterates—*radial symmetry*, wherein the organs are arranged in a circle about a central axis, so that the body is the same all round. In *bilateral symmetry*, seen in mammals, birds, and almost all animals more highly organised than Cœlenterates, there is a distinct right side and left side and only along one central plane can the body be halved so that the halves are alike. A few creatures, such as snails, are *asymmetrical*, there being no plane whatsoever along which they can be divided so that the halves may be similar.

The Cell.—It must be emphasised that the basis of all the complicated structures exhibited by the animal world is the cell—a microscopic unit in which are hidden the problems of life and death. An animal cell consists of two main types of protoplasm. The predominant cell substance or *cytoplasm* is a foam-like or net-like substance with hollow spaces containing a watery fluid, or other non-living matters such as yolk globules, fats, or pigments, manufactured by the cell and known as *metaplasm*. At times also there becomes apparent in the cytoplasm a temporary body—the *centrosome*—which seems to guide the multiplication of the cell into two. The other type of protoplasm is the *nucleus*. This differs in chemical properties from the cytoplasm, since it combines more readily with basic substances, whereas cytoplasm shows affinity for acids. The nucleus lies in the midst of the general cell material and contains two elements: a matter readily stainable by dyes (hence *chromatin*), consisting of grains arranged in complicated threads, networks, or rods, and a less stainable substance which appears to form a network supporting the chromatin—the *linin* or *achromatin*. The nucleus seems to be of vital importance in the economy of the

cell, for its removal causes the death of the whole cell, although when a portion of the nucleus is left the cell survives.

THE DEVELOPMENT OF THE INDIVIDUAL

In an earlier section there have been mentioned the modes of reproduction—divided into two groups, asexual or vegetative, and sexual—whereby from a parent stock new individuals arise. Whether many-celled animals originate by asexual or sexual means, their growth in size is based upon successive divisions of individual cells. This process of division is so similar in the majority of cases that its complexities can be stated in a general way.

The Basis of Growth in Many-celled Animals —Division of Cells.—In a growing cell the bulk increases more rapidly in proportion than the surface, so that the latter is unable to absorb nutriment or to get rid of waste products with sufficient rapidity to allow growth to continue. Thus a definite limit is reached at which, if growth is to go on, the cell must divide. The process is heralded by the splitting of the nucleus, which plays an essential rôle in cell division. In a limited number of cases the nucleus becomes constricted and simply splits into two, each half forming the centre of a new cell (*direct* or *amitotic division*). But the typical method is much more complicated, involving an orderly rearrangement of the nuclear substance (*karyokinesis*). The chromatin threads which normally form a coil in the nucleus, gradually unfurl and arrange themselves in a star lying round the equator of the cell. An attracting centrosome appears at each pole of the cell; each thread splits horizontally into two, and one half of the now duplicated star is drawn to the north, another to the south pole. Then, and not till then, does the cell show any sign of division. But now a cell wall forms between the two separated halves of the star, each of which becomes shut off in a compartment of its own—a new cell. In this, with its threads twisted and coiled as at the first, the divided star becomes the nucleus. Each of these new cells finally reaches the limit of growth and then proceeds to divide as did the parent cell.

This complex division is the means of growth and comprises the secret of such development as the budding or asexual multiplication of sponges or Cœlenterates; but in sexual reproduction the normal cell-division is preceded by a peculiar process of fertilisation and follows a more or less constant course of development in the early stages.

Sexual Fertilisation.—Before growth can begin in sexual reproduction there must be (except in parthenogenesis) a union between a male cell or spermatozoon, and a female cell, the egg or ovum. This union is preceded by a preparation or "maturation" of both cells. For in both the nuclear elements, present in definite numbers in the cells of every species, divide into two equal lots, one of which (a "polar body") is cast outside the cell, so that the number of elements retained is only half the normal number. The process indeed is somewhat more complicated, but after it follows fertilisation, when the head of the spermatozoon bearing the nucleus penetrates the egg-cell, and the depleted nuclei of egg and sperm fuse intimately, forming a new single nucleus which —the sum of two halves—contains again the full number of chromosomes. In this intimate mixing (*amphimixis*) of the strains of male and female parents lies the possibility of the wonderful variation which characterises the progeny of sexual union.

The Early Development of the Fertilised Egg. —The intimate fusion of the nucleus of the male cell with the egg nucleus stimulates the egg or female cell into growth. It divides—to take a typical case—into two, then into four, eight, sixteen cells and so on, with the result that a solid globe of cells (*morula*) is formed. The globe increases in size and a cavity arises within it—this hollow ball being now known as a *blastula* or *blastosphere*. A part of the wall becomes dinted in, and a thimble-shaped *gastrula* results, with two distinct layers of cells —the outer wall or *ectoderm*, and the inner indented wall or *endoderm*. Between the two a middle layer or *mesoderm* develops in most animals. These layers constitute the first specialisation or differentiation of the embryo, and in all animals each gives rise by further cell division and specialisation to distinct types of organs. From the ectoderm arise the outer skin and its products—nails, hair, and horny armour—the nervous system, and portions of the sense organs and food tract; from the mesoderm develop the lower skin layer (*dermis*), muscles, bone, blood-vessels, and heart; and from the endoderm originate such organs as the notochord, and the mid-portion of the food tract with the liver, kidneys, lungs, etc.

In spite of these general facts, however, the details of development differ much in different groups of animals. But in most the energy of growth is furnished by a supply of nutritive yolk within the egg, upon which the embryo is sustained until it can fend for itself; and to the presence of varying quantities of this food supply the differences in the early development or *segmentation* of the embryo are mostly due.

During their early development the young of higher vertebrates—reptiles, birds, and mammals—are protected and nourished by characteristic membranes—the *amnion*, which forms a sac containing watery fluid in which the embryo lies, and the *allantois* with a respiratory as well as a yolk-absorbing function. In mammals (except Monotremes) an extraordinary develop-

ment of the latter membrane occurs, for, yolk being practically absent from the egg, the young are nourished directly by the blood of the mother, with whose body they are intimately connected by the *placenta*, a structure formed in great part from the allantoic membrane.

It is obvious that the time occupied by the development of the individual should vary with the kind of animal. An Amœba can divide into two complete Amœbæ in the course of a few hours, and colonies of Hydroid Zoophytes have been observed to spring up, and reach maturity in a very few weeks. In the higher animals, however, the periods are as a rule considerably lengthened. Many fishes, although their embryonic stages may be short, reach full development only after the lapse of years: the salmon in its third year makes for the sea, and does not return to fresh water to breed until at earliest the following year; the fresh-water eel spends almost its whole life in immaturity in ponds and streams, and at the end makes for the sea to lay its eggs and die. The prolongation of both embryonic and immature development is still more marked amongst birds and mammals; and it is significant that, in a very general way, the longer the vital connection between mother and unborn young, and the longer the period of tuition during which the incapable young share the attentions and guidance of their parents, the higher the development of the group or species to which they belong.

The minute study of the early stages of development in different types of animals has led to a generalisation of wide interest—the Recapitulation theory—which may be appropriately discussed in the next section.

THE DEVELOPMENT OF THE RACE

Just as observation has shown that each individual undergoes an orderly development from apparently simple to more complex stages, so, we assume, the animal world, beginning in simplicity, has gradually attained more highly specialised and more highly organised stages. The great steps in this evolution cannot be demonstrated, for they have occupied thousands of years and occurred in periods known only to the geologist and palæontologist, yet the main facts are indicated by several lines of evidence.

Thus **Palæontology,** the science which reads in fossils the past history of life, although it gives us no complete view, shows us glimpses of the steps of life's progress. It may reveal simply the stages by which one species passed into another, as in the case of the fossil pond-snails (*Viviparus* or *Paludina*) in the Pliocene strata of Slavonia. Individuals from the lowest and the highest of these strata seem to belong to two distinct species, yet in the intermediate layers specimens have been found which reveal the stages by which the higher developed from the lower form. Or again, it may trace the unfolding of definite characters. Thus in early Tertiary times the ancestors of the Horse possessed five toes on each foot. These primitive forms were succeeded by species in which successive reductions in the number of toes occurred, until at the end of the series there appeared in Pliocene times representatives of the domesticated horse (*Equus*) with only one toe on each foot. Still again, palæontology may bridge the gaps between great resting-places in evolution, by revealing a missing link: the toothed Jurassic bird, *Archæopteryx,* although clearly a feathered bird, shows distinct traces of derivation from reptilian stock; and the Mesozoic *Dinosaurs,* although clearly reptilian, possess characters which point to the evolution of birds.

A wider view of the results of palæontological study is no less effective. Most main groups of invertebrate animals had already evolved ere the oldest fossil-bearing rocks known to us had consolidated, but the order in which the higher vertebrates arose has been revealed: the first fossil fishes, amphibians, reptiles, and birds following each other in succession just as the zoologist, on grounds of their structural complexities, had classified them in ascending order.

Structural Tests.—It seems logical to assume that life began at its simplest, and from this reached higher and higher stages of perfection. Thus we place an animal in the scale of life as "low" or "high" according as its structures and functions are simple and more generalised or complex and more specialised. Such a conception gives us a guide to the development of animal life, but further evidences are revealed by the minute study of definite structures, whose progressions in complexity and efficiency in different forms, often indicate the relationships of these forms; or by the occurrence of "vestigial structures"—disappearing and often functionless organs—which point to an ancestry which possessed the structures in functional perfection.

Recapitulation.—Another line of evidence is furnished by the development of the individual. In the stages of embryonic growth an animal passes again to some extent over the path trod by its ancestors—it *recapitulates* the history of the race. In following the development of the individual, in the preceding chapter, we were to some extent following the development of the race. For every individual begins as a single cell (the ovum)—and the starting point of the animal kingdom was the single-celled Protozoa; the ovum becomes a ball of cells (*morula*)—and some Protozoa increased in complexity by the union of many cells into a ball (*Volvox*); the morula becomes a two-layer thimble-shaped sac (*gastrula*)—and some of the simplest of many-celled animals are two-layered thimble-shaped sacs (Hydrozoa). So

the course of racial development is roughly repeated over and over again. Even in more advanced embryos of higher forms the general resemblances to lower forms are evident. The embryos of mammals possess gill-slits, of which no use is ever made, but these point to the path of evolution of mammals through lower vertebrate forms; for in these—fishes and amphibians—gill-slits are universally functional. Many larval or embryonic forms supply a key to the relationships of their kind, which could never be discovered by study, however close, of the adult forms alone.

From such lines of evidence zoologists have endeavoured to group the animal world in a "natural" classification which exhibits, so far as can be fathomed, the actual course of evolution. From the starting point of single-celled animals a short step is made upwards to many-

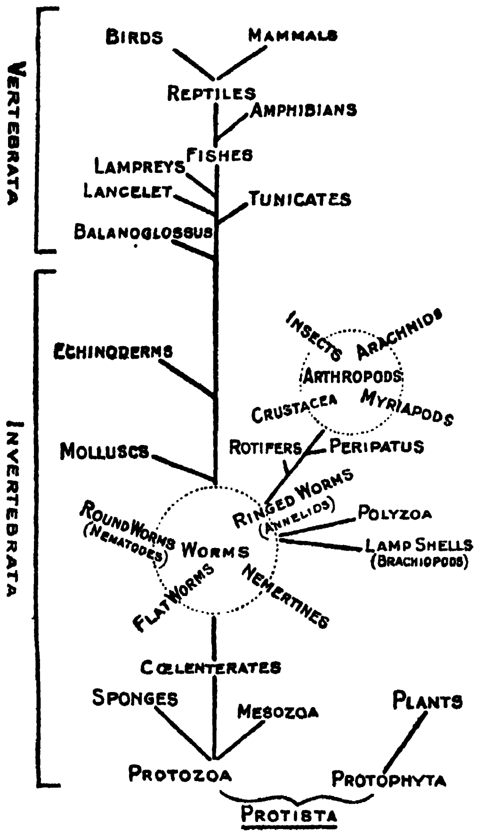


FIG. 8.—The Tree of Life.

celled animals; and from the many ramifications of the Invertebrates among these, a long stride to the Vertebrate groups. The evidences are complicated and not always definitive, but a rough scheme of the gradual growth of the tree of animal life is here given, and portrays in a crude way the relative positions of the main groups of animals in the upward progress of evolution.

THE MAIN DIVISIONS OF THE ANIMAL WORLD

Amongst the many hundreds of thousands of different kinds of animals which people earth, and air, and sea, one fact is patent—that all are not equally different. Thus, no matter how they may differ amongst themselves, the 50,000 known species of butterflies and moths bear a family resemblance to each other. Their resemblance to bees or beetles, let us say, is apparent, though less evident, but to fishes they bear no resemblance at all. Similar close and more distant likenesses are apparent throughout the animal kingdom, so that by a judicious selection of test characteristics we are enabled to split up the animal world into great divisions (or phyla), the members of any one division bearing more resemblance to each other than to the members of any other division. Not only is this grouping of similar animals a matter of convenience, but endeavours are made to use "natural" characters in the grouping, so that the divisions express real relationships and not merely chance resemblances. That is to say the members of a division or phylum bear kin to one another in that they have developed or evolved from a common ancestor or from a few ancestors closely related.

Such natural divisions having been formed, it becomes clear that they differ in several ways from each other. One division may contain almost innumerable multitudes of species, another may comprise only a few; the members of one division may be creatures of simple structure, those of another may be highly complex. It is natural to arrange the divisions from lower to higher—the lower animals being those whose structures, in different degrees, are most generalised and simple, the higher those wherein increasing complexity of structure is evident. Thus is built a "tree of life" (such as that illustrated in the preceding section, Fig. 8) which expresses as closely as possible the natural and gradual evolution of animals from the simplest Protozoa to the most highly developed birds and mammals. But it must not be forgotten that the pictorial representation is false in so far as the branches are shown on this side or that, whereas the real growth proceeds in all directions round the main trunk of evolution.

In the following pages will be found summaries, necessarily of the shortest kind, of the leading features of the chief animal divisions—commencing with the lowest and proceeding to the highest. A word of explanation may be given regarding the uses of Latin names by which animals are universally recognised. The

large divisions or phyla are subdivided into many grades. All animals practically identical with each other are grouped in the lowest grade —a *species*. Thus all lions belong to one species, *Felis leo;* all tigers to another species, *Felis tigris;* all leopards to another, *Felis pardus;* and so on. But there is a close resemblance between lions, tigers, and leopards, and this relationship is expressed by grouping them in the same *genus*—the distinguishing mark of the genus being that each bears the same name, *Felis*, as the first part of the binomial specific name. Related genera again are grouped in a *family*, as Felidæ—the Cat Family; related families in an *order*, such as Carnivora, which embraces cats, dogs, bears, and seals; and related orders make a *class*—Carnivores being united with monkeys or primates, ungulates (cattle kinds), &c., in the class Mammalia; while related classes, such as mammals, birds, fishes, &c., are grouped in the grand division or *phylum*, Vertebrata.

INVERTEBRATES

or

BACKBONELESS ANIMALS

Invertebrate animals are characterised, as the name implies, by the absence of a backbone, or, more accurately, by the absence of an internal dorsal axis, for not all vertebrates have a backbone, though all have such a dorsal axis. But a few other characters are generally shared by invertebrates as contrasted with vertebrates: thus none have gill-slits; the eye arises from the external skin, the heart is on the upper or dorsal side of the body, and the nerve cord is on the lower or ventral side, at least in the invertebrates in which those organs occur. The groups of invertebrates are much more diverse than are the groups of vertebrates; indeed the latter form a single phylum *Vertebrata* equivalent as an evolutionary stage to any one of the many invertebrate phyla.

PHYLUM **Protozoa—The Simplest Animals** (Gr. *protos*, first; *zoon*, an animal).—The only animals in which all the bodily functions are concentrated in a *single cell* or bead of jelly-like protoplasm—so simple that they are scarcely to be distinguished from single-celled plants. The single cell, generally microscopically small, consists essentially of a body mass of protoplasm which contains one or more nuclei, food vacuoles with digestive ferments, contractile vacuoles which eject waste products, and many small granules in the cell substance. Most have naked bodies, but some such as Foraminifera and Radiolarians secrete protective shells or skeletons of lime or flint, and others build "houses" of sponge-spicules, diatom valves, and such like. The ordinary functions of a Protozoon such as *Amœba* are described in an earlier chapter on the "primary functions" (p. 793).

Protozoa occur in fresh water or in the sea all the world over. They feed on bacteria, diatoms, or on decaying vegetation, but many are parasitic, living in larger animals, occasionally interfering with the health of their hosts, and even causing death. Amongst such dangerous parasites are Trypanosomes (the cause of sleeping-sickness) and Sporozoa. Some Protozoa, such as Infusorians and Flagellates, render service to man by purifying waters of harmful bacteria, and the Foraminifera and Radiolaria of past ages have shared largely in the formation of limestone and chert rocks.

PHYLUM **Porifera** or **Sponges** (Lat. *porus*, a passage; *fero*, I bear).—The simplest of many-celled animals, without external organs, sometimes tough and fleshy in texture like the bath sponge, or hard and stony, or leathery, or net-like, or resembling spun-glass. The living sponge is composed of many cells forming a delicate tissue which is supported on a skeleton formed of multitudes of usually minute rods or *spicules*. These may be composed, in different species, of carbonate of lime (calcite), of flint (oxide of silicon), or, in such as the toilet sponges, of a horny organic substance (*spongin*). Characteristic of all sponges are *collar-cells* (Figs. 9, B, and 10), with whip-like flagella which, by constant lashings, drive through the sponge tissue, by way of the surface pores, a current of water, whence microscopic food —diatoms and protozoa —is extracted. Sponges may propagate their kind asexually by simple budding or by the production of seed-like gemmules, but sexual reproduction is more common.

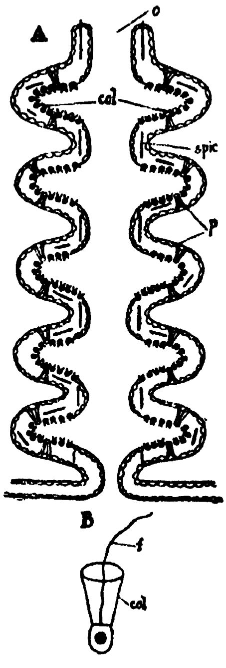


Fig. 9.

A, diagrammatic longitudinal section of a simple Sponge. The collar-cells and spicules are represented in black; *B*, a single collar-cell enlarged; *col* in *A*, collar-cell; *col* in *B*, collar-cell; *o*, osculum; *P*, pore; *spic*, spicule. Highly magnified.

All sponges are aquatic: a few inhabit fresh water, but the vast majority live in the sea, from shore rocks to the greatest depths, and from the tropics to the polar circles. Most are attached to the bottom, spreading over a rock surface (*e.g.* Breadcrumb Sponge, *Halichondria*), solidly fastened by a stout stalk (*e.g.* Neptune's Cup Sponge, *Poterion*, or Purse Sponge, *Sycon*), or anchored by long glassy "root" threads in

the mud (*e.g.* Glass Rope Sponge, *Hyalonema*, or Venus's Flower Basket, *Euplectella*). The "sponges" of commerce are simply the cleaned skeletons of varieties of *Euspongia* found in the Mediterranean Sea and West Indies.

FIG. 10.—Section of Toilet Sponge (after Lydekker) with Flagellated Chambers. Highly magnified.

are amongst the oldest animals known, for their fossil remains have been found in rocks of Cambrian Age.

PHYLUM **Cœlenterata—Stinging Animals**

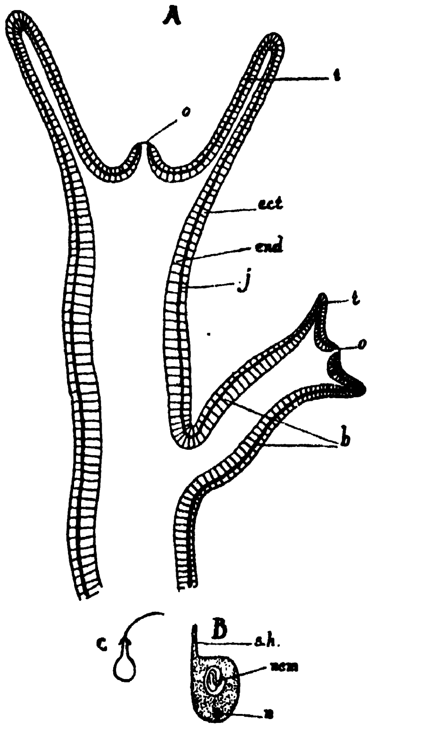


FIG. 11.

A diagrammatic longitudinal section of a simple Cœlenterate with a bud attached; *B*, a stinging-cell (cnidoblast) with a nematocyst inside; *C*, a discharged nematocyst; *b*, bud; *ect*, ectoderm; *end*, endoderm; *j*, jelly; *n*, nucleus; *nem*, nematocyst; *o*, mouth; *s.h.*, sense-hair; *t*, tentacle. Highly magnified.

(Gr. *koilos*, hollow; *enteron*, inside).—A large phylum including polyps, jelly-fishes, corals, and sea anemones. All are of simple structure, generally a two-layered sac—the external layer protective ectoderm, the internal digestive endoderm—with a mouth at one end surrounded by food-catching tentacles (Fig. 11). Characteristic of Cœlenterates are *stinging-cells* or *cnidoblasts*, minute sensitive cells embedded in the ectoderm, which contain a barbed thread steeped in poison (Fig. 11, B and C). This thread is suddenly ejected when the creature is irritated, and entering its enemy or prey, stupefies and kills it.

Cœlenterates are propagated by budding or by sexual reproduction. Many exhibit a curious *alternation of generations*, a plant-like stock or polyp colony giving rise asexually to small jelly-fishes containing sexual products, whence in turn a polyp colony again develops.

With very few exceptions they live in the sea, either attached to the bottom, as the plant-like zoophytes (*Hydrozoa*), the sea anemones, and the corals whose limy skeletons build the great coral reefs of tropical seas (*Anthozoa*); or floating freely in the open waters, as the jelly-fishes (*Scyphomedusæ*) and the sea-blebs (*Ctenophora*).

They belong to an ancient race, for abundance of coral skeletons and of the Hydrozoan Graptolites are found fossilised in the oldest (Palæozoic) rocks.

PHYLUM **Platyhelminthes—Flat Worms** (Gr. *platus*, flat; *helminthoi*, worms).—Amongst "worms," in the popular sense, occur creatures of such different types that they have to be segregated in different phyla. Of these the flat worms are the simplest. They have generally flattened bodies, lack a blood system, and the food canal, when present, has no posterior opening. But flat worms show an advance on Cœlenterates in possessing bilateral symmetry and a central nervous system with a miniature brain of two nerve ganglia. They include three classes: the carnivorous **Turbellarians** or **Planarians (Leaf Worms)**, found free in fresh water, in the sea, or on land; the **Trematodes (Flukes, Liver-Flukes,** &c.), external or internal parasites, one of which causes "liver-rot" in sheep; and the **Cestodes** or **Tape Worms,** found parasitic in almost all vertebrate animals, species of *Tænia* being formidable human parasites, and *Cœnurus* causing "staggers" or "gid" in sheep.

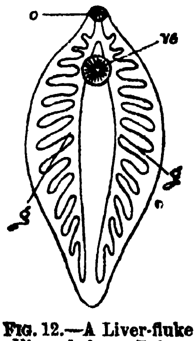


FIG. 12.—A Liver-fluke Viewed from Below. Enlarged.

g, branches of gut; *o*, mouth; *vs*, sucker.

PHYLUM **Nemertea or Nemertinea—Round Worms.**—Carnivorous, round-bodied worms found most often on the seashore, though a few live in fresh water or on land. They are characterised by a long

protrusible trunk or proboscis (Fig. 13), by a coat of fine cilia covering their skin, by the presence frequently of several groups of eyes, a blood system, and a simple brain. In particular they show an advance on flat worms in possessing a food canal open at both ends, a swallowing aperture or mouth at the head end, and a hinder aperture or anus by which waste material is ejected.

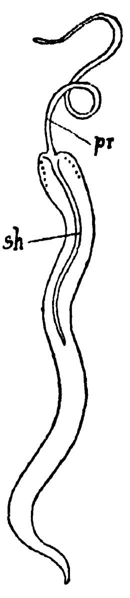


FIG. 13.—A Nemertine Worm Viewed from Upper Surface. Natural size.

pr, proboscis; *sh*, sheath of proboscis.

PHYLUM **Nematoda—Thread-Worms** (Figs. 14 and 15).—Ivory-white or transparent smooth-bodied worms most of which are parasitic, although some live in soil, and others in fresh and salt waters. They may be microscopic or up to a yard long, and are distinguished by a thick protecting cuticle, under which lies the muscular system — a layer of longitudinal muscles. There is a well-developed food canal with mouth and anus, and an anterior pore with which is associated a peculiar excretory apparatus. Between food canal and muscles lies a space filled with fluid—a primary body-cavity. The life-history is often complicated, different stages developing in different habitats or hosts. The maw worm (*Ascaris*) and whip worm (*Trichocephalus*) are common intestinal parasites in man; the Guinea worm (*Filaria*) causes painful abscesses; and *Trichina*, swallowed with infected

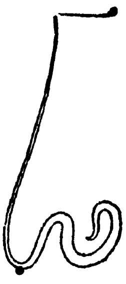


FIG. 14.—A Nematode Worm. Natural size.

o, position of mouth.

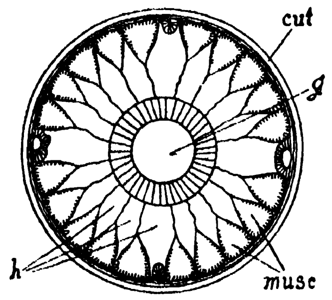


FIG. 15.—Diagrammatic Cross-section of a Nematode Worm. Highly magnified.

cut, cuticle; *g*, gut; *h*, hæmocœle or primary body-cavity; *musc*, muscle cells.

pig's-flesh, causes the occasionally fatal disease, Trichinosis.

PHYLUM **Nematomorpha — Hair Worms.** — Long, unsegmented, dark brown, hair-like worms with degenerate food canal. They occur in ponds and ditches among water weeds, and although free when adult, they pass various stages of their existence in different aquatic insects. A common Hairworm is *Gordius*.

PHYLUM **Annelida—Ringed Worms.**—The most familiar of "Worms," including the marine worms, often used for bait, the earth worms, and the leeches. All have ringed or segmented bodies, often with the external rings continued in partitions across the body-cavity, dividing it into a series of similar segments (*somites*). The

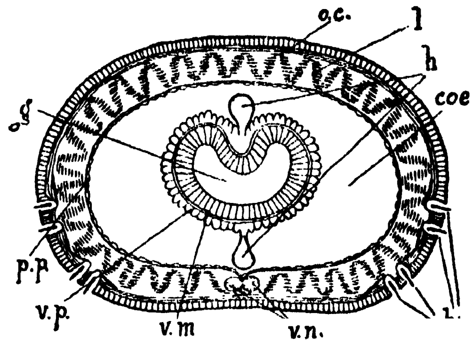


FIG. 16.—Diagrammatic Cross-section of Earthworm as example of an Annelid Worm. Highly magnified.

br, bristles; *coe*, cœlom or secondary body-cavity; *g*, gut; *h*, blood-vessels representing the hæmocœle; *l*, longitudinal muscles; *o.c.*, outer circular muscles; *p.p.*, parietal peritoneum; *v.m.*, visceral muscles; *v.n.*, ventral nerve-cord; *v.p.*, visceral peritoneum.

head is usually well developed. There are several sets of muscles, a brain of two nerve ganglia, a ventral nerve cord also with ganglia, and a nerve collar connecting brain and cord. For the first time in the animal world a secondary body-cavity or cœlom appears, separating food canal from muscles and allowing independent action in each. Two groups are of main importance —CLASS I. The **Chætopoda** or **Bristle Worms** (Gr. *chaite*, bristle; *pous*, *podus*, foot), including **Polychæta** (Gr. *polus*, many)—the **Sea Worms,** such as the lob-worm—almost without exception found in shallow water or floating in the sea. They have a distinct head, with tentacles, eyes, and horny jaws, external gills, and rows of prominent bristles, and the young stage is unlike the adult; and **Oligochæta** (Gr. *oligos*, few)—the **Earth Worms**—distinguished by their terrestrial habit, lack of distinct head, of external gills, of prominent bristles, and of a transitional larval stage.

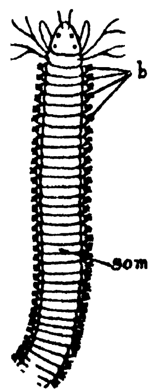


FIG. 17. — Upper View of Bristle Worm. Nat. size.

br, metamerically repeated bristles; *som*, a somite.

CLASS II. **Hirudinea** or **Discophora—Leeches** —with oval flattened bodies, without bristles or external gills, but generally with a sucker at each end, the anterior formed by the mouth.

They are mostly external parasites, living in fresh water or on land, and feeding on the blood of snails, fishes, or larger vertebrates. A few, such as the rock or skate leech, are marine.

Several classes of animals, the exact status of which is unknown, although they are apparently related to the Annelid worms, may be mentioned here. They include the Arrow worms—CLASS **Chætognatha**—translucent animals, up to 2½ inches long, which float in the open sea; the **Wheel Animalcules**—CLASS **Rotifera**—mostly microscopic inhabitants of fresh water, furnished with a crown of cilia which in motion has the appearance of a rotating wheel; the **Lamp Shells** — CLASS **Brachiopoda** — molluscan-like marine animals in which, however, the two shell-valves are dorsal and ventral, and there are complicated mouth appendages supported in some by a limy skeleton; and the **Sea Mats** —CLASS **Polyzoa**—minute polyp-like creatures

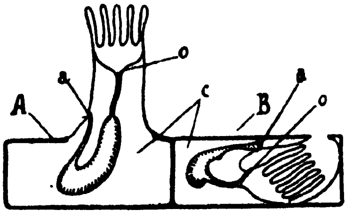


FIG. 18.—Diagram showing two Individuals of Polyzoon Colony. Highly magnified.

A, with extended, and *B*, with retracted, polypide; *a*, anus; *o*, mouth; *c*, cœlom.

which form plant-like colonies mostly with limy skeletons, found encrusting sea-weed, or growing on rocks and stones in the sea (Fig. 18).

PHYLUM **Arthropoda—Jointed-limbed Animals** (Gr. *arthron*, a joint; *pous*, *podos*, foot).—Bilaterally symmetrical, segmented animals, with variously modified jointed appendages, and generally possessing a hard protective cuticle formed of horny chitin strengthened by deposits of lime. This armour makes necessary periodic moulting during growth. There is a dorsal brain, a double ventral nerve chain with ganglia, and a nerve ring round the gullet, connecting the two. They comprise many familiar and important classes, containing in all more than half a million distinct species.

CLASS I. **Onychophora** (Gr. *onux*, *onuchos*, a claw; *phoros*, bearing) contains the primitive *Peripatus* which links the Annelid worms and the Arthropods—soft-bodied, shy, insectivorous animals, found only in the Southern hemisphere and India, with caterpillar-like bodies, breathing by a system of tracheæ, and furnished with from seventeen to forty-three pairs of legs. The indistinct head bears two sensitive antennæ, at the bases of which lie the eyes.

CLASS II. **Crustacea.**—A large assemblage of creatures most of which are aquatic. They are characterised by a strong chitinous armour impregnated with carbonate of lime, and a body divided into head, thorax, and abdomen, all of which bear appendages, two-branched on thorax and abdomen. They breath by gills, or directly through the skin, and exhibit great activity. Their development is usually indirect, several larval stages being passed through. The Crustacea include the brine-

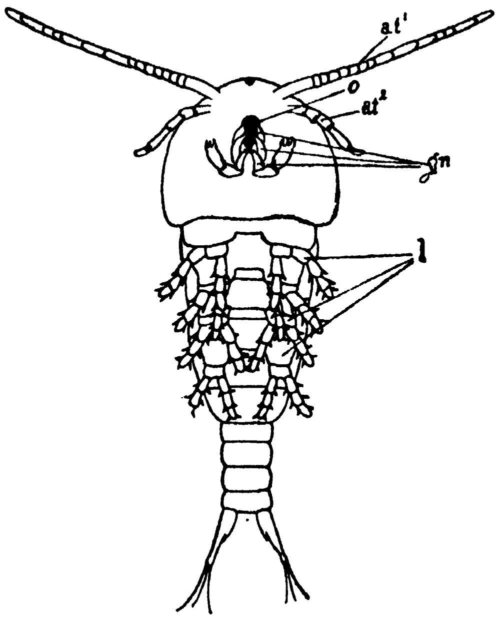


FIG. 19.—A Water-flea as an example of a Crustacea Viewed from Below. Highly magnified.

*at*¹, first antennæ; *at*², second antennæ; *gn*, jaws; *l*, walking legs; *o*, mouth.

shrimps or *Branchiopoda;* the fresh-water *Cladocera* or water-fleas; the minute, bivalved *Ostracoda;* the *Copepoda*, whose vast numbers form an important food supply of marine fishes, although some, such as the "fish-lice," are parasitic; the marine *Cirripedia*—barnacles and acorn-shells. The *Isopoda*, with body flattened from above downwards, include many marine forms, such as the wood-destroying Gribble (*Limnoria*), as well as the terrestrial wood-lice or slaters. The laterally-flattened *Amphipoda*, such as the shore-fleas or sand-hoppers (*Talitrus*), and the fresh-water "shrimp" (*Gammarus*), are abundant in the sea, and rare in ponds and lakes. All the orders of Crustacea already mentioned contain members with sessile eyes, but in the higher groups the eyes are perched on movable stalks. Such are the *Schizopoda*, small shrimp-like forms found in the open and the deep sea, often with phosphorescent organs; and the most familiar group of all, the *Decapoda*. These, characterised by the possession of ten walking legs, comprise

the *Macrura*, *e.g.* the long-bodied lobsters, crayfishes, shrimps, and prawns; the *Anomura*—*e.g.* hermit-crabs, the stone crab (*Lithodes*), and the robber crab (*Birgus*); and the *Brachyura*—the short-bodied true crabs, such as the edible-, shore-, swimming-, river-, and land-crabs.

The remains of simple Crustacea are found as fossils in the oldest fossil-bearing (Cambrian) rocks, but the higher forms became common only in Cretaceous times.

Class III. **Myriopoda—Centipedes and Millipedes** (Gr. *myria*, ten thousand; *pous, podos*, a foot).—Land animals found in almost all parts of the world. They differ much in feeding habits, but in shape they have in common a long body with many segments and many pairs of legs, and a distinct head. The head bears one pair of jointed antennæ, eyes formed of groups of simple eye-spots, and two or three pairs of jaws. The remains of myriopods have been found in the Old Red Sandstone rocks of Scotland, belonging to Devonian Age. **Centipedes** have flattened bodies, only one pair of legs on each segment, long antennæ, a first pair of legs modified as poison claws, and they are carnivorous in habit. **Millipedes** possess rounded bodies, two pairs of legs on each segment, short antennæ, no poison claws, and their diet is vegetarian.

Class IV. **Insecta or Hexapoda—Insects.**—The most numerous, in individuals and in species, of

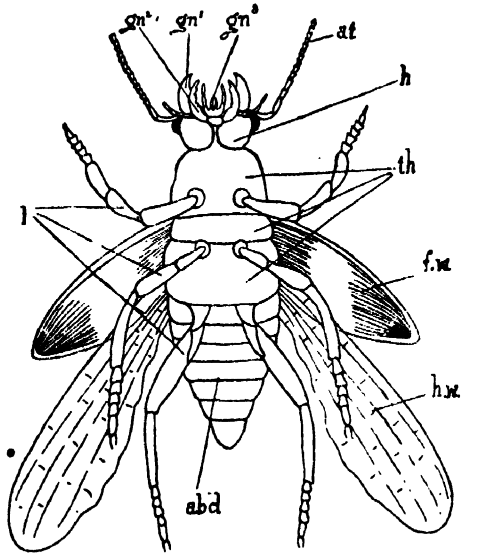


Fig. 20.—A Beetle Viewed from Below as an example of Insecta. Magnified.

at, single pair of antennæ; *abd*, abdomen; *f.w.*, fore wing; gn^1, gn^2, gn^3, the three pairs of jaws; *h.w.*, hind wing; *h*, head; *l*, walking legs; *th*, thorax.

the inhabitants of the land. Their bodies are divided into three distinct regions—head, thorax, and abdomen—the first bearing a pair of feelers or antennæ, three pairs of complicated jaws, and two compound, with sometimes additional simple, eyes; the thorax, with three segments, bearing *six* pairs of walking legs (hence *Hexapoda*) and, as a rule, two pairs of wings; and the abdomen, of nine or ten segments, lacking appendages. Insects breathe by means of air tubes or tracheæ communicating with the exterior and ramifying throughout their bodies. Most pass through young stages which differ from the adult, and the degree of change is known as incomplete or complete metamorphosis. Insects are exceedingly active creatures, and frequent earth and air, but a few are aquatic and more spend a part or the whole of their larval life in water. Of recent years the class of insects has been broken up into a great many orders, but for convenience sake we mention here only the nine wide orders into which the members of the class are more frequently grouped. It must be remembered, however, that the vastness of the study of insects has given rise to a distinct science—Entomology—an important branch of which devotes its attention to the numerous species which are harmful or beneficial to man, his live stock, and his crops.

Order I. **Aptera** (Gr. *apteros*, wingless)—**Spring-tails, bristle-tails,** &c.—Minute, wingless insects, with body covered by scales and hairs. The mouth is adapted for sucking, and the young resemble the adults.

Order II. **Orthoptera** (Gr. *orthos*, straight; *pteron*, a wing)—**Cockroaches, locusts, grass-hoppers, earwigs, leaf and stick insects.** &c.—Forewings stiff, and often modified into covers which protect the hinder flight-wings. Mouth parts adapted for biting. Incomplete metamorphosis, the young lacking wings.

Order III. **Neuroptera** (Gr. *neuron*, a nervure; *pteron*, a wing)—**Dragon flies, caddis flies, lace-wing flies, may flies, termites or white ants,** &c.—Two pairs of membranaceous flight-wings, closely meshed with nervures; mouth parts for biting; incomplete or complete metamorphosis.

Order IV. **Thysanoptera** (Gr. *thusanos*, a fringe)—*Thrips*.—Minute insects with four very narrow wings fringed with hairs, but often with wings reduced or absent. There is no metamorphosis, the young being similar to the adult; the mouth parts are adapted for sucking, and damage is occasionally done to corn crops, onions, &c.

Order V. **Coleoptera** (Gr. *koleos*, a sheath)—**Beetles.**—*see* Fig. 20. Forewings hard and horny, modified into close-fitting covers which protect the hinder flight-wings, these being folded when not in use. Mouth parts for biting; and metamorphosis complete, a larval or grub stage, quite unlike the adult, being succeeded by a quiescent pupal stage, during which the adult form is built up. About 150,000 species are known.

Order VI. **Hymenoptera** (Gr. *humēn*, a membrane)—**Saw flies, gall flies, ichneumon flies, bees, wasps, ants,** &c.—Active, neat insects with four generally transparent wings, the fore and hind wings locking together during flight. The body has often a narrow "waist," and the females possess a sting, saw, or boring or piercing ovipositor. The mouth parts may be for biting or sucking; and there is complete metamorphosis, the larvæ being footless grubs. Between 30,000 and 40,000 species are known.

Order VII. **Hemiptera** (Gr. *hemi*, half)—**Bugs, water scorpions, lice, plant lice, scale insects.**—With four wings, the fore pair generally firm in texture, and used as covers for the hinder pair. Mouth parts forming a jointed sucking proboscis. Generally no metamorphosis.

Order VIII. **Diptera** (Gr. *di-ptera*, two-winged)—**Flies.**—With two membranous, usually transparent wings. Mouth parts adapted for sucking; metamorphosis complete, the larvæ being footless maggots or grubs. Some are dangerous carriers of disease, owing to their scavenging habits, as the house fly; or owing to their blood-sucking propensities, as mosquitoes and the Tse-tse fly.

Order IX. **Lepidoptera** (Gr. *lepis*, a scale)—**Butterflies and moths.**—With four large wings covered with minute scales. Mouth adapted for sucking; metamorphosis complete, the larva being a caterpillar. Of the 50,000 species known, many are large and brilliantly coloured. The silk-worm moth is of great economic value.

CLASS V. **Arachnida.**—A heterogeneous group of insect-like animals in which the anterior segments are generally fused to form a cephalothorax with six pairs of appendages. The two anterior pairs are modified for seizing food, the first being known as chelicerae, and the remainder are walking legs. The young generally resemble the adults. The following are important classes of arachnids: the **Scorpions** (*Scorpionidæ*), with lobster-like claws, and an elongated abdomen bearing a spine with poison gland; the **Spiders** (*Araneidæ*), with first appendages modified as poison fangs, and many with silk-secreting "spinnerets"; the **Mites** and **Ticks** (*Acarina*), with head, thorax, and abdomen fused, frequently with parasitic habits; the king crab (*Xiphosura*), with horse-shoe shaped cephalothorax and abdomen ending in a long spine, an inhabitant of shallow tropical seas; and the extinct **Eurypterids** and **Trilobites** found as fossils in Palæozoic rocks.

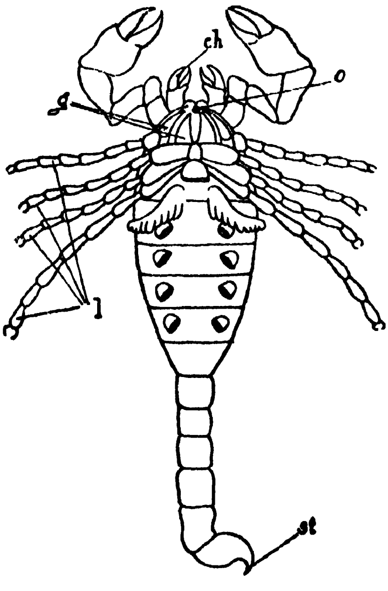


FIG. 21.—A Scorpion as an example of Arachnida Viewed from Below. Nat. size.

ch, chelicerae; *g*, chewing processes borne at the bases of *l*, the walking legs; *o*, mouth.

PHYLUM **Mollusca—Molluscs, "Shell-fish."**—Unsegmented animals with bilateral symmetry (lost, however, in adult gasteropods), and in most a prominent shell of carbonate of lime. They have no jointed appendages, but move by means of a muscular mass on the under surface—the "foot." Breathing is by gills, as well as directly through the skin. There is a moderately simple nervous system; and generally an ill-defined head, with tentacles possessing the power of smell, a chitinous band or radula within the mouth for rasping food, and complicated eyes. The body is usually slimy, owing to secretions from numerous gland-cells. Molluscs are, as a rule, sluggish animals, and of the 25,000 species scattered all over the world, the majority live in the sea or fresh water, although some, such as slugs and snails, frequent land. To man they are of value as food, and as furnishing pearls and shells highly appreciated as ornaments. They fall into five great classes.

CLASS I. **Pelecypoda** (Gr. *pelekus*, an axe; *pous*, *podos*, a foot) or **Lamellibranchiata, Bivalves.**—The body is concealed within a shell having two valves, hinged by a chitinous ligament. There is no head, and no radula; the eyes are numerous but simple, set along the edges of the shell-forming mantle. The hinder portion of the mantle forms a tube or

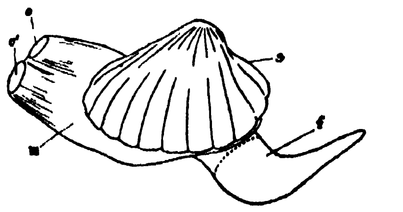


FIG. 22.—Side View of a living Cockle as an example of the division of Mollusca called Pelecypoda. Reduced.

f, foot; *m*, mantle; *o*, o^1, two posterior openings between joined mantle-flaps; *s*, shell.

siphon by which water is conducted to and away from the plate-like gills. Almost all the 5000 species known live in the sea, and include such forms as mussels, cockles, razor-shells, oysters, scallops, and the ship worm, *Teredo*.

CLASS II. **Scaphopoda** (Gr. *skapos*, a boat; *pous*, *podos*, a foot) includes *Dentalium*, the Elephant's Tooth Shell—a simple animal without distinct head, eyes, or heart. It forms a tubular shell open at both ends, and lives only in the sea.

CLASS III. **Solenogastres** (Gr. *sōlēn*, a pipe; *gaster*, the belly)—*e.g.* *Neomenia*, degenerate worm-like forms lacking shell, but with rudimentary radula.

CLASS IV. **Gasteropoda** (Gr. *gaster*, belly; *pous*, *podos*, foot) or **Univalves**.—Easily distinguished by their single or univalve shell, but in slugs and some marine forms no shell is apparent, and *Chiton* and its allies bear a series of shell plates. The foot is flattened for crawling; there is a distinct head, with radula and tentacles, upon or at the base of which are the eyes. The majority of the 17,000 species

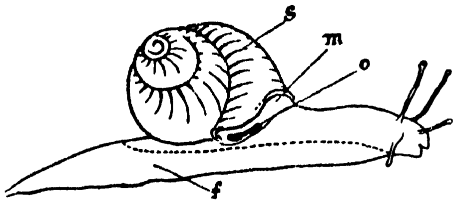


FIG. 23.—Side View of a living Snail as an example of the division of Mollusca called Gasteropoda.

f, foot—the dotted line, as in Fig. 22, shows the upper limit of the muscular portion *m*, mantle; *o*, opening between mantle and body; *s*, shell.

known are marine, most of these, such as limpets, whelks, periwinkles, cowries, *Chiton*, being found upon shore rocks, while a few float in the open sea, as the sea butterflies (Pteropods). But over 6000 species, slugs and snails, live on land or in fresh water.

CLASS V. **Cephalopoda** (Gr. *cephale*, head; *pous*, *podos*, foot)—**Cuttle-Fishes**.—The most

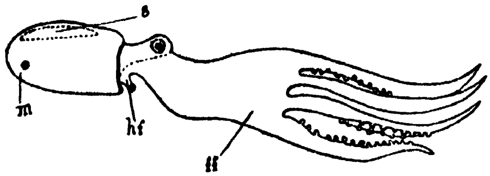


FIG. 24.—Side View of a Cuttle-fish swimming, as an example of the division of Mollusca called Cephalopoda. Reduced.

ff, fore-foot produced into arms bearing suckers; *hf*, hind-foot or funnel—the dotted line shows upper edge of foot; *m*, mantle; *s*, concealed shell.

highly developed of mollusca; with the front portion of the foot surrounding the head and prolonged into the very characteristic "arms" bearing suckers or tentacles. The mouth lies in the midst of the arms, has strong horny jaws and a radula. The distinct head bears two highly developed eyes. The nervous system is highly developed; and the shell, except in the pearly nautilus, is buried within the body. Cuttle-fishes either crawl by means of their arms, or swim backwards by ejecting water through a funnel or siphon. All are marine and carnivorous. They include the extinct ammonites and belemnites, the squids, cuttle fishes, octopus, the paper nautilus (*Argonauta*), and the pearly nautilus.

PHYLUM **Echinodermata** (Gr. *echinos*, hedgehog; *derma*, skin)—**Prickly-skinned Animals.**

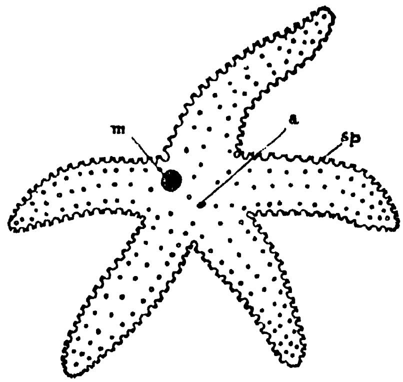


FIG. 25.—Upper View of Common Star-fish as an example of Echinodermata. Reduced.

a, anus; *m*, madreporite; *sp*, spines.

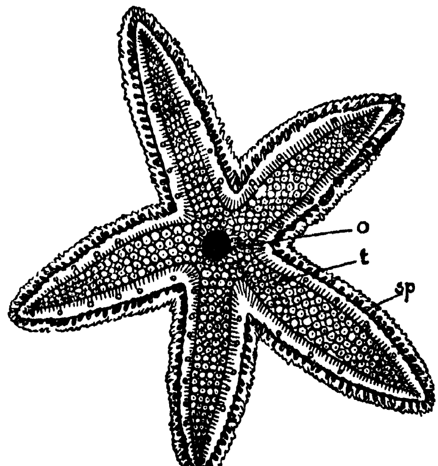


FIG. 26.—Under View of Common Star-fish as an example of Echinodermata. Reduced.

o, mouth; *sp*, spines; *t*, tube-feet.

—Many familiar creatures characterised by the possession of a radially symmetrical body, and

a skeleton of limy plates or rods, apparent in most as projecting spines. They move sluggishly by means of sucker- or tube-feet actuated by a peculiar water-vascular system. All are marine, and many possess an extraordinary power of regenerating lost portions of their limbs or body. Echinoderms fall into five classes:

CLASS I. **Asteroidea** (Gr. *aster*, **a star**; *eidos*, shape)—**Starfishes.**—Star-shaped creatures with five or more arms not clearly marked off from the body. The mouth is in the centre of the under surface, and they are carnivorous (Figs. 25 and 26).

CLASS II. **Ophiuroidea** (Gr. *ophiouros*, serpent-tailed)—**Brittle Stars.**—Star-shaped, with a disc-like body, on the edge of which are inserted five long, snake-like arms, covered by a close armour of plates. The mouth is on the under surface, and they feed on small animals.

CLASS III. **Echinoidea** (Gr. *echinos*, hedgehog)—**Sea Urchins.**—Globular, heart-shaped, or disc-like animals, covered with spines set on a limy skeleton composed of ten double series of close plates, through half of which tube-feet project. They feed mainly on seaweed, which is chewed by a peculiar five-toothed mill—"Aristotle's lantern."

CLASS IV. **Holothuroidea—Sea Cucumbers.**—Sausage-shaped, mostly soft animals with limy skeleton often reduced to small hidden plates. The mouth is at one end of the "sausage," and is surrounded by tentacles, which collect the mud whence organic food is extracted.

CLASS V. **Crinoidea** (Gr. *krinon*, a lily)—**Sea Lilies** and **Feather Stars.**—Plant-like animals highly impregnated with calcareous matter with cup-shaped bodies from which spring delicately branched limy arms. Most are attached to the bottom by a long limy stalk, and inhabit the deep sea. The mouth is on the upper surface, and they feed on minute animals.

VERTEBRATES
or
BACKBONED ANIMALS

So far we have discussed in brief the many Phyla of the lower animals. Standing in similar rank with these, on account of the affinities of its members, is the great Phylum which includes the remainder of living things—the Vertebrate or Chordate Phylum. Vertebrates as a whole are to be distinguished from Invertebrates by the possession of a backbone, or at least of a dorsal axis—the notochord—the precursor of a backbone. Other common characters are: the presence of gill-slits, if not in adult then in embryonic stages; the eye mainly developed from the brain; the heart placed towards the ventral side; and the main nervous structures—brain and spinal cord—on the dorsal side.

It must not be supposed that the Vertebrate type was developed in a day. The gradation of Evolution's steps leads one to expect to find creatures which have only gained in part the full attributes of the backboned. Such animals we find: a group of creatures standing on the threshold of Vertebrata—and on this account grouped together as:

PHYLUM **Protochordata** (Gr. *protos*, first).—Diverse animals which stand in the gap between invertebrates and vertebrates. They show close relationship to the vertebrate stock

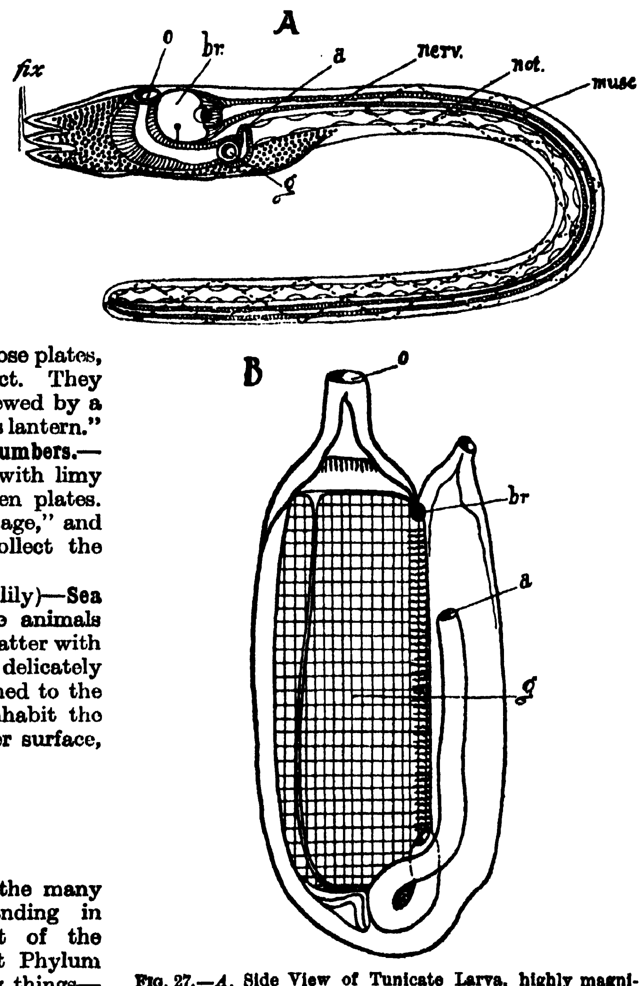


FIG. 27.—*A*, Side View of Tunicate Larva, highly magnified; *B*, Side View of Adult Tunicate cut open, nat. size.

a (in *A*), position of future anus; (in *B*), anus; *br* (in *A*), hollow brain vesicle; (in *B*), ganglion remnant of larval brain; *fix*, papillæ by which the larva attaches itself; *g* (in *A*), single gill-pore on one side; (in *B*), trellis-work on side of the adult gullet which develops out of the gill-pore of larva; dotted lines indicate outlines of muscle cells which flank the tail on either side; *nerv.*, spinal cord of larva; *not.*, notochord or rudimentary backbone of larva.

in possessing an elastic rod-like axis—the notochord; perforations leading from the pharynx to the exterior—gill-slits; and a dorsal nervous system. They include three classes:

CLASS I. **Hemichordata** (Gr. *hemi*, half)—*Balanoglossus*, *Cephalodiscus*, *Phoronis*, &c.—A miscellaneous group of small worm-like marine animals with a reduced notochord, situated in most in a proboscis-like extension in front of the mouth.

CLASS II. **Cephalochordata** (Gr. *cephalon*, the head)—*Amphioxus* or *Branchiostoma*—**The Lancelet.**—Marine, free swimming, somewhat fish-like animals with an unsegmented body, but with the internal organs disposed in segmental order. The notochord runs the whole length of body and head.

CLASS III. **Urochordata** (Gr. *oura*, the tail)—**Tunicates** or **Sea Squirts.**—Marine animals found in all seas from shallow to deep water. Their chordate characters are most distinct in the larval stages, which swim freely by means of their tail. In this the axis is formed by the notochord. The adults are mostly degenerate and fixed to the sea-bottom. They are protected by a thick, tough test or "tunic," pierced by two openings, by which water currents enter and issue; within the test is a large sieve-like pharynx with gill-slits, and a simple tubular heart which reverses the blood-current periodically.

PHYLUM **Craniata—The True Vertebrates.**—This great clan of the higher chordate animals, distinguished primarily by the possession of a skull and a brain, is divided into six great classes, the relationships of which to one another in the evolutionary advance are fairly clear. Thus we can trace with little hesitation not only the gradual advance of one class from its lowest member to its highest, but the main outline of the steps whereby one class led to the next, by which, for example, the fish type rose to the amphibian type, and this to the reptilian, and so on. Here, however, we can scarcely do more than give in most summary form the main characters of the six classes:

CLASS I. **Cyclostomata** (Gr. *kuklos*, circle; *stoma*, mouth)—**Hag Fishes** and **Lampreys.**—Primitive eel-shaped "fishes" with round mouths adapted for sucking, without jaws, scales or paired fins, and with paired gill-pouches. The skeleton is composed of cartilage only. Hags and lampreys live in the sea, though some of the latter frequent fresh water. They are semi-parasitic, and live on fishes.

CLASS II. **Pisces — Fishes.**—Typically spindle-shaped, cold-blooded vertebrates wholly adapted for an aquatic life. The influence of their habitat is shown in their shape—head, trunk, and tail graduating imperceptibly into each other so as to offer the minimum of resistance; and in their muscular bodies, the muscles being arranged in flakes or myotomes, and actuating their swimming organs or fins. Of these the paired fins represent, and are therefore said to be *homologous* with, the limbs of higher vertebrates. The body is generally protected by close rows of scales. Fishes are furnished throughout life with gills, which extract oxygen dissolved in the water, and so purify the blood. The majority of their senses, especially smell, touch, and sight, are acute, though in some deep-sea forms the eyes are degenerate, their function being replaced by tactile organs. Most fishes live in the open water of seas, lakes, or rivers, where they swim actively, but some, such as the globe fishes, float almost passively in the sea; others frequent shore areas, while many, such as the flat fishes, are specially adapted for life on the sea-bottom. Their food varies much: shore fishes are often vegetarian, living upon seaweeds, but the greater number are carnivorous. According to their diet they possess flat crushing, or sharp biting teeth. Influenced by the need of food or by the necessities of suitable breeding localities, many species perform great migrations, some (*e.g.* salmon, eels, sturgeon) even moving to and fro between the sea and fresh water. A few bony fishes and sharks bring forth living young, but most lay enormous numbers of eggs (the cod over four millions annually), which are fertilised and hatch externally. The remains of fishes occur as fossils from Upper Silurian times onwards.

The three main groups of fishes are: The **Cartilaginous Fishes,** or **Elasmobranchii,** with a cartilaginous skeleton, small enamelled bony (placoid) scales, and no air-bladder or lung. Such are the sharks, dog fishes, skates, and Chimæra. The **Teleostomi**—including the vast majority of fishes—distinguished by the possession of a more or less bony skeleton, of soft, circular (cycloid) scales, of a bony protection to the gills (operculum), and of an air-bladder, which often aids in purifying the blood. In this group are congregated the old-fashioned Polypterus, the sturgeons, Lepidosteus, and the true bony fishes, such as carps, eels, the salmon family, herrings, the cod family, flat fishes, perches, and globe fishes. The third group consists of the highly specialised **Mud or Lung Fishes—Dipnoi,** with skeleton partly bony, partly cartilaginous, cycloid scales, an operculum, and an air-bladder which acts as a lung, sending purified blood to the heart, already incipiently three-chambered. Such are Ceratodus, Protopterus, and Lepidosiren.

CLASS III. **Amphibia—Amphibians** (Gr. *amphi*, double; *bios*, life).—A class of cold-blooded vertebrates so clearly related to fishes, and possessing so many characters along with them, that Huxley placed both in a comprehensive group—Ichthyopsida. Amphibians, however, show some advances in specialisation over fishes, and these chiefly in relation to the transition from

aquatic to terrestrial life which they exhibit. Thus, though most pass through a gill-breathing stage, adult amphibians usually possess no gills, the place of gills in respiration being taken by air-breathing lungs. The limbs, instead of being mere paddles (fins), are limb-like and are furnished with digits. Unpaired fins, where present, are much less effective swimming organs than the fins of fishes, and have no fin-rays. There are no scales, and the skin is slimy owing to the presence of numerous gland-cells—a protection from terrestrial foes. Other characteristics of amphibians are a three-chambered heart, and an outgrowth of the gut which foreshadows the allantoic membrane of fœtal higher Vertebrates. Amphibians are represented, so far back as Carboniferous times, by the gigantic and often armour-plated **Stegocephali** (Labyrinthodonts, &c). Amongst modern amphibians are reckoned the **Toads** and **Frogs**, which in adult life are four-limbed, tailless, and gill-less; the **Newts**, with tailed adults, often possessing gills, and frequently lacking hind limbs; and the snake-like, limbless, blind, subterranean forms such as *Cœcilia*.

CLASS IV. **Reptilia—Reptiles.**—A class of cold-blooded vertebrates linked backward with amphibia, and more intimately forward with birds and mammals. They generally possess a lengthy body, with a strong tail—the main organ of locomotion, four limbs, except in snakes and a few limbless lizards, and an external armour of scales or horny plates. This scaly protection is regularly cast or sloughed, either in fragments or, as in snakes and many lizards, as a whole. At no stage do reptiles possess functional gills, breathing being entirely by lungs. The heart shows a gradual advance in efficiency—three-chambered in most, in crocodiles four-chambered. Reptiles lay large eggs, protected by a limy or membranous shell, and the embryos are sheltered by two membranes—the allantois and the amnion—the latter a sort of water-jacket found also in birds and mammals.

Reptiles are predominantly carnivorous and terrestrial, but show much diversity of habit. Many crawl on the surface, some burrow underground, turtles and a few snakes are aquatic, others live in trees, and flying lizards and the extinct pterodactyls have in some degree conquered the air. The earliest reptilian remains occur as fossils in Permian rocks, but in Jurassic and Cretaceous times they were the predominant inhabitants of air, land, and water.

The 5000 species of reptiles of the present day fall into five groups or orders, distinguished most effectively by skull characters—the New Zealand lizard-like Hatteria or Sphenodon (*Rhynchocephala*); the **Lizards** (*Lacertilia*), mostly with scaled bodies and four limbs; the limbless, scaled **Snakes** (*Ophidia*), with expansible mouth; the vegetarian **Tortoises** and **Turtles** (*Chelonia*), without teeth, and protected by a strong case of bones overlapped by scales of "tortoise-shell"; and the carnivorous, fresh-water **Crocodiles, Alligators**, and **Gavials** (*Crocodilia*), with long heavy skulls well supplied with teeth, and a long body protected by strong epidermal scales.

CLASS V. **Aves—Birds.**—So closely are birds related to reptiles by many structural peculiarities that Huxley united both these classes of vertebrates in a comprehensive group—Sauropsida. But the resemblances mark at best a far-back connection; for the light-bodied, warm-blooded, superbly active birds have advanced far in the path of specialisation beyond the highest point attained by the heavy, cold-blooded, sluggish reptiles. Along with mammals, birds share the place of honour at the top of the evolutionary tree, and although these classes have specialised along very different lines, both probably arose in past ages from reptilian stock. The most striking features which birds share amongst themselves are connected with two peculiar developments—their conquest of the air, and their extraordinary activity. Associated with the former are the boat-like shape of their bodies, the modification of their forelimbs into organs of flight, or wings, the hollowness, and therefore lightness of the bones of most, the stability gained by the high position of their lighter organs, such as lungs, and the low position of the heavier organs (the larger muscles and digestive apparatus), and the rigidity of skeleton gained by the cementing together of many of the elements of the backbone and by the relationships of the components of the skeleton. Associated with their great activity is their high body temperature, exceeding even that of mammals by 2° to 14° Fahrenheit, their coating of feathers which retains warmth while adding the minimum of weight, and the presence of air-sacs which supplement the lungs, and in many species are prolonged into the bones and amongst the internal organs. Possibly their song is also an expression of activity finding emotional outlet. The heart is four-chambered. Like reptiles, birds lay large eggs, protected by a limy shell, from which young, closely resembling the parent, hatch.

But apart from their structural characters birds exhibit in their habits features no less distinct. Thus the majority build nests, some with a marvellous delicacy of design and execution, and most rear their young with great care. The varieties of shape and colouring of their eggs are well known. Of all creatures they have most widely adopted the migrating habit, a necessity forced upon them primarily by changes in food supply; and the distances which they cover, and the accuracy with which they make for and arrive at the haunts of former years, are almost incredible.

Birds have evolved as a predominant class

in comparatively recent periods. The remains of the earliest bird—Archæopteryx—with toothed jaw, and jointed tail, occur in Jurassic strata, but few indeed are the fossilised bird-relics which are found before Tertiary times.

Modern birds, all of which fall into the sub-class **Neornithes**, are grouped into running or keelless, and keeled birds.

Running or **Keelless Birds (Ratitæ)** possess no powers of flight, but instead run rapidly, using their wings as air-paddles. They have no ridge or keel along the front of the breast-bone. There are few representatives—the African ostrich, the American rhea, the Australian emeu and cassowary, and the New Zealand kiwi or apteryx.

Keeled Birds (Carinatæ) include the remainder of existing birds, all of which possess a ridge or keel on the front of the breast-bone, to which flight muscles are attached. The 11,000 known species have been grouped into thirteen orders, mainly on account of differences in the structure of the palatal bones, and on account of the degree of perfection of the young when they leave the egg. Of these orders the most familiar are the Colymbiformes—divers and grebes; Anseriformes—ducks and geese; Falconiformes—birds of prey; Galliformes—game birds; Gruiformes—coots, cranes, and rails; Charadriiformes—pigeons, gulls, and plovers; Cuculiformes—cuckoos and parrots; and Passeriformes—song birds.

CLASS VI. **Mammalia—Mammals** (Lat. *mammæ*, breasts).—The class of vertebrate animals to which man belongs, and which, on account of the unified complexity of its structures, shares with birds the summit of the evolutionary tree. Like birds they probably originated from a reptilian stock. Mammals are warm-blooded, but their most characteristic feature is that to which they owe their name—the presence of mammary glands which secrete milk for the nourishment of the young after birth. The milk glands may simply open on a bare patch of skin, from which the young lick the milk, as in Echidna, but in the higher mammals they are associated with teats, by which the young are suckled. Of all animals mammals alone are furnished with hair, although in some, such as whales, where warmth is retained by a thick layer of blubber, the hair is reduced to a few bristles on the lips. The brain is very highly organised; and the body is divided by a diaphragm or midriff into an upper half containing lungs and four-chambered heart, and a lower containing the digestive apparatus. Many other characters mark mammals off from other vertebrates—such as the presence of sweat-glands, of only seven neck-vertebræ (except in four cases), and of biconcave non-nucleated red blood corpuscles. The differentiation of the teeth is also characteristic.

Mammals are predominantly inhabitants of the land, but whales and their allies occur in the sea, and bats have conquered the air. The majority are carnivorous, but many are vegetarians, and some feed only on insects and other invertebrates. To man they are of the utmost value, for not only do they furnish him with abundance of food supply and of raiment, but their adaptability to domestication lightens many of his heavier toils.

Mammals fall into three great groups:

SUB-CLASS I. **Prototheria, Ornithodelphia,** or **Monotremata.**—Primitive egg-laying mammals, with mammary glands simply opening on a bare patch of skin, a comparatively simple brain, and a blood temperature of only 25° to 28° C. They include the Porcupine Ant-eater—Echidna, and the Duck-bill—Ornithorhynchus.

SUB-CLASS II. **Metatheria, Didelphia,** or **Marsupialia,** with prematurely-born young which are nourished after birth in a pouch or marsupium provided with teats, with a brain with or without simple convolutions, and a blood temperature of 32° to 36° C. Such are opossums and bandicoots, wombats, phalangers, and kangaroos.

SUB-CLASS III. **Eutheria** or **Monodelphia,** with young vitally connected with the mother before birth by an allantoic placenta, and after birth able to suck, with a highly developed and convoluted brain, and a blood-temperature of 35° to 40° C. Into this sub-class fall the majority of mammals, grouped in nine orders.

Order I. **Edentata (Sloths, Ant-eaters, &c.).**—Often altogether lacking teeth, and always without median teeth and enamel on the teeth.

Order II. **Sirenia (Dugongs** and **Manatees).**—Adapted for aquatic life, with flippers and fluke-like tail, a rounded skull, and teats on the breast.

Order III. **Cetacea (Whales and Porpoises).**—Large marine mammals with flippers and fluke-like tails, an elongated skull, and teats placed far back on the body.

Order IV. **Ungulata (Hoofed Mammals).**—Long-limbed, active mammals with the tips of the digits on both feet protected by a hoof. They include the elephants, odd-toed ungulates (*Perissodactyla*), such as horses, rhinoceroses, and tapirs, and even-toed ungulates (*Artiodactyla*), such as the hippopotamus, pigs, camels, deer, cattle, and giraffes.

Order V. **Rodentia (Rodents).**—With chisel-shaped front (incisor) teeth—hares, rabbits, squirrels, rats, and mice, beavers, and porcupines.

Order VI. **Carnivora (Carnivores).**—With strong cutting and holding teeth, the eye-teeth or canines being large and curved, and with sharp powerful curved claws—cats (lions, tigers, leopards, &c.), dogs (wolves, prairie dogs, &c.), bears, weasels. Seals and sea-lions are specially adapted for life in the sea, their limbs being modified into flipper-like organs.

ORDER VII. **Insectivora (Insectivores).**—Small

land mammals with sharp-edged back-teeth, adapted for insectivorous diet, often having a flexible highly-sensitive snout, and a brain of low mammalian order. They include moles, shrews, and hedgehogs.

Order VIII. **Chiroptera (Bats).**—Flying mammals resembling insectivores in the simplicity of their brains, and in the character of their teeth, but with the forelimbs modified into wings, a fold of skin being stretched over the much lengthened fingers, and hence along the arm to the shoulder.

Order IX. **Primates.**—Large-brained mammals, with long limbs, forward-looking eyes surrounded by bone, five fingers and toes, some with nails, the big toe and thumb so set as to grasp against the remaining digits (except the big toe of man, and the thumb of marmosets). Most primitive of the primates are the lemurs, small furry monkeys with fox-like faces. Amongst the higher or anthropoid monkeys, characterised by much greater brain development, by the setting of the eye in a complete bony cup, and the sideways touching of the front teeth, are the New World monkeys (Platyrrhina), such as the marmosets and American monkeys; the Old World monkeys (Catarrhina), such as the African baboons, the sacred Indian apes, the chimpanzees, orang, and gorilla; and most highly developed of all, distinguished by his erect gait, fine forehead and brain, and mental development—Man.

SOME GENERALISATIONS REGARDING ANIMAL LIFE

The observed and recorded facts regarding the structures and lives of animals form the raw material of the philosophy of zoology. Far-seeing minds have selected from this indiscriminated mass of knowledge here a fact and there a fact which, brought into juxtaposition, have given them a glimpse of wider truths underlying the seeming irrelevancy, and enabled them to bring from confusion order. These wider views are embodied in the ideas, hypotheses, theories, and generalisations which endeavour to crystallise the so-called "laws" of organic nature, and to demonstrate the unity which, it must be assumed, underlies all the manifestations of life. In earlier chapters of this article there have been indicated some of these generalisations, such as the idea of the Recapitulation of ancestral evolution in individual development, and that of the upward progress of life associated with the increasing differentiation and integration of parts. Here we shall discuss briefly some of the theories to which in recent years most attention has been directed.

Heredity.—Heredity expresses in a word the most patent relationship between parents and progeny—that the offspring resembles in particular its parents and forebears, and in general the race to which it belongs; in well-worn phrase, that "like begets like." The reason of this hereditary resemblance lies in the fact that the sex-cells from which each individual springs are not the creation of individual parents, but are handed down in unbroken line through succeeding generations—a phenomenon known as the "*continuity of the germ plasm.*" The offspring, then, is not an isolated product, but is simply a scion or sideshoot of a long line of ancestors. Heredity is the total inheritance with which a new generation starts, before outside influences have begun to tell upon it. Clearly both parents, themselves the composition of a long heritage, contribute most (the proportion is one half) to the "inheritance" of their progeny, but the contributions may be expressed in various ways. Thus in one or all of its characters the offspring may take after one of its parents only: it may have its father's eyes, or its mother's hair (exclusive inheritance); or the parental characters may be obviously compounded, as in a piebald foal born from self-coloured parents (particulate inheritance). In other cases there is a subtle mingling of features, as when from the crossing of long-eared and short-eared rabbits a breed with ears of intermediate length results (blended inheritance); and in yet other cases the children in nowise resemble their parents, but "throw back," to some more or less distant ancestor, as in the indiscriminate interbreeding of domesticated rabbits of different colours, when an ultimate result is the production of a grey coat similar to that of the ancestral wild rabbit (reversion). Finally the offspring, freeing itself from ancestral influence, may develop a new character of its own. This, a type of variation known as discontinuous variation, "freak" or "sport," may more properly be discussed in the section following—on Variation.

Of the various theories which have been adduced to explain the appearance of parental characters in the next generation, that known as the *Mendelian hypothesis*, or *Mendelism*, has gained wide support. Mendel discovered in 1865, and many experimenters in recent years have added additional proof, that in certain cases certain characters (unit characters) of parents do not blend in the offspring. So when two Mendelian parents are crossed the first "hybrid" generation resembles one of the parents only—the characters of the other remaining latent or "recessive." But when the "hybrids" are crossed amongst themselves a marvellous result is apparent, for the second hybrid generation exhibits in their purity the diverse characters of the two grandparents, and these characters appear in definite proportions of the progeny. This strange result is explained by the hypothesis of *segregation*: that the unit characters are "segregated" in different groups of germ-cells in the first hybrids, and that in the crossing of these hybrids the unit characters

rearrange themselves according to the physical laws of chance grouping. Mendelian inheritance has been proved for a considerable number of animals—rabbits, rats, mice, farmyard fowls, canaries, silk worms, beetles, &c., and for many plants; but it is doubtful whether it is of general application.

Variation.—In the preceding section the resemblance which persists between generations has been emphasized—"like begets like." But at the same time it must not be forgotten that the children of the same two parents, notwithstanding that they draw their inborn characteristics from the same ancestral line, never resemble each other in all the details of feature, stature, and temperament. Herein is variation.

The variations most obvious to the casual observer are those embodied in changes of stature, of bulk, of length or number of various parts (meristic or quantitive variation); but the less patent mental qualities, the chemical composition of tissues and such like, are also liable to vary (qualitative or substantive variation). In general, however, all variations fall into one or other of two groups—they are either continuous or discontinuous.

Continuous Variation.—A name for the all-pervading type of variation exhibited in little differences, up or down, in the characters derived from parents or race. Such differences are universal, for careful observation and exact measurement applied to the same structure in many representatives of any species of animal show that the structure varies between a highest and a lowest limit. It has a range of variation; and this variation is continuous in that we can trace a gradual, step by step, divergence from the normal up to and down to each limit.

Discontinuous Variation.—Here we can trace no such gradual development of the variation. The new character appears suddenly, without warning, as it were: it is a "freak," a "sport." A crab may have a double pair of pincers, a starfish an extra arm, the progeny of horned cattle may be polled—without horns, and so on. The importance and interest of discontinuous variation lies in this, that many of the sports or mutations which arise discontinuously are permanent acquisitions which are passed on from one generation to another.

Variations are of significance not only from their own immediate point of view, but also because of the effect they exercise upon the organism as a whole. An animal acts as a unified organism, and it is natural to suppose that variation in one organ or function must induce a related variation in associated organs or functions. Such interlocking variation is termed *correlated variation.*

Much is still obscure, however, regarding the occurrence of variability. It used to be held that domesticated animals and plants were more liable to changes in character than their wild relatives. And although this opinion is probably erroneous, it would appear that certain conditions—such as great alteration in the environment of animals or plants, or certain qualities of climate—stimulate increased variability. Further, it has been shown in some cases that variation is more rife in the younger than in the older stages of an animal's existence.

Variations are either impressed upon an organism by its environment, or are the expression of subtle changes in the germinal cells. In the former case, such as the darkening of the human skin by the sun, they develop during the creature's existence, and are merely, as it were, surface imprints which affect the individual, but not its progeny. In the latter case, they are expressions of a radical change within, and are so interwoven in the very nature of the organism that they become part and parcel not only of the individual in which they first appear, but of its offspring also. Of the final cause, or of the means of such germinal changes, we are entirely ignorant.

The Response to Environment.—So vital is the responsive power of organisms in the development of life that it cannot be dismissed in a word. It stands along with the inheritance of ancestral and racial characters as a guiding power which has moulded the forms of plants and animals, and has determined the paths of organic progress. But environment in this connection must be taken in its widest sense, as including not only the inorganic surroundings with which an animal comes in contact, but its animate associates as well.

We have already seen in the simplest animals, such as Amœba, that the proximity of a deleterious substance causes an immediate reaction—the retiral of the Protozoon. Now it seems to be an inherent property of protoplasm that a stimulus often repeated, and always calling forth a response, finally induces in the protoplasm a counter effect which is more or less permanent. And herein lies the importance of organic response. It is a familiar fact that continued manual labour renders the skin of the hands thick and horny, or that the muscle which is repeatedly exercised becomes on this account more firm, larger, and more efficient.

A wide survey of animal life gives us the same impression of adaptation to the demands of environment. Creatures whose habits lay them specially open to the attacks of enemies are protected by thick coats of armour, by close-set bristles, by the secretion of poisonous slimes, by colouring which renders them inconspicuous. Flying animals are furnished with wings, of very different origins, and are built so as to offer the least resistance to the air; arboreal creatures have prehensile structures;

land animals possess long limbs for progression; the inhabitants of the waters, even when they belong to groups so different as whales, seals, and fishes, are torpedo-shaped, so that they may penetrate their heavy surroundings with ease, and have paddle-like swimming organs. Such adaptations, and the animal world teems with them, we look upon as manifestations of the response to environment.

Direct experiments have shown how immediate in some cases is the effect of changed circumstances. Caterpillars fed on food plants different from their usual diet may change in colour, and may even develop into butterflies in which the coloration differs from that of the ordinary imago. Differences of temperature and of moisture also produce unexpected effects, as in the potato-beetle (*Leptinotarsa*), in which Professor Tower discovered that females subjected to moist conditions produced a majority of dark-coloured (melanic) offspring, whereas dry conditions induced offspring in which pigmentation was lacking (albinic).

But the effects and importance of organic response cannot be better exemplified than in the behaviour of man under certain disease conditions. In the cases of such diseases as scarlet-fever, chicken-pox, small-pox, measles, and others, one effect of the attacking organism is to cause a counter stimulation in the system, with the result that "anti-bodies" inimical to the disease are formed in the blood. These, should they conquer the disease, still remain in the human system and retain their effectiveness, with the result that the person affected is immune from the specific disease against which the anti-bodies have responded.

The ultimate value in racial development of this remarkable power of response in organisms will be more clearly shown in the succeeding remarks on Evolution.

Evolution—The Origin of Species.—The idea of evolution in the world of nature is no new idea, although only recently has its full import been grasped. The significance of this conception of a gradual unfolding of life from lowly simple stages, by slow advancing steps, to highly complex stages, may best be grasped by a glance at the opinions which it has supplanted. To Linnæus and his disciples life was no orderly progressive march. The forms of life—species—were to him definite entities which from time immemorial had been, and to all time would be, the fixed invarying beings he regarded them. They were the results of a Special Creation which had planted them complete and final upon the earth. True, a species had offspring, but for the offspring the path was determined; for to all generations it could never depart from the parent's road.

How different from this inelastic view of life and its functions is that of evolution. Even in the fifth century B.C. Empedocles, "the father of the evolution idea," had suggested that the four elements, played upon by love and hate, yielded plants and animals, some of which were successful and survived. In the following century that fine observer, Aristotle, with remarkable insight, held that nature was a unified development in which living things formed a continuous line of descent which in the beginning had sprung from inanimate matter. The evolution idea fell on good soil, and, in spite of the Linnean dogma, many of the eighteenth-century naturalists, notably Erasmus Darwin and Buffon, sought in the action of environment, the struggle for existence, natural selection, and isolation, vague keys to the causes of variation in living things. So were foreshadowed the great truths which Lamarck and Charles Darwin and their successors were to place on a more firm basis.

In the chapter upon "The Development of the Race" (p. 799) there have already been discussed the evidences which, taken together, indicate that life is a gradual development: that the animals which people the earth are connected with each other in long lines of descent, so that no matter how different they may appear, all living things are blood relations descended from simpler and still simpler ancestors. Further, in examining in the earlier sections of the present chapter the powers of inheritance and of variation possessed by the organism, and the responses which it makes to environment, we have seen the working factors upon which evolution depends. The ground being thus cleared our remaining remarks may be devoted to the summarising of the two main theories which endeavour to explain the actual working of evolution in nature—those of Lamarck and Darwin.

Lamarckism.—Lamarck's theory of evolution lays stress on the organic response to environment. By use an organ increases in efficiency, through disuse it degenerates. Therefore a creature had simply to determine to use an organ whose development was necessary, and the organ, responding, would develop to suit the need. Such development, however, would obviously affect only the individual concerned, but Lamarck's theory went further. It held that such "acquired characters," if sufficiently impressed upon the individual, were directly transmitted to the offspring: that the gain of the individual was the gain of the race.

This assumption is the great weakness of Lamarckism. For though experiment after experiment has been made no satisfactory proof has ever been forthcoming that "acquired characters" are transmissible from one generation to another. Consequently the theory has fallen into abeyance.

Darwinism.—Darwin's theory of evolution laid stress on the fact of variation. All animals in nature produce far more offspring than can

possibly find food. In a single season a female cod spawns on an average 4,398,700 eggs. Obviously all cannot survive to a mature age; and the resulting contest for food and survival is the "struggle for existence." But in deciding which shall perish and which shall survive, nature comes into play. For, since variation is a fact, all the offspring are not alike, and those which are crushed out of existence are those whose variations fit them less than their brothers and sisters for the capture of food or for escape from enemies. So "natural selection" determines the survivors in the "struggle for existence," and determines what variations shall be perpetuated. The organism here is passive, and new forms are simply those which have escaped Nature's pruning knife. In Lamarckism, on the other hand, new forms were the direct outcome of the organism's activity.

But, though Darwinism may explain the origin of some new species, it too has its difficulties. The small fluctuating variations postulated by Darwin must in many cases be so insignificant in their beginning that they cannot one way or another affect the creature's chances of survival. Indeed many variations have been preserved and perpetuated which can have no influence, so far as we can see, in the struggle for existence. A single example will illustrate the point: one family of two-winged flies is divided into great groups according to whether one or two bristles are present on the fore part of the thorax, or whether there are three or four bristles on the hind part. Such distinctions seem trivial from the point of view of utility, and yet they have been perpetuated in large numbers of species.

We are forced to the conclusion, then, that neither of the great theories of the origin of species altogether meets the requirements demanded of it. Each no doubt contains a germ of the truth; but while we admit the great fact of Evolution, and the gradual development of life from more simple to more complex forms, we are still far from a full knowledge of the working methods by which Nature guides evolutionary progress.

COURSE OF READING

The study of animals ought in the main to be a practical study. The zoologist is a person interested in animals, and not in books about animals. And yet it is necessary that the worker should be able to gain with rapidity the fundamental facts on which that branch of the science which particularly appeals to him is based. Recourse in such a case can only be had either to a practical teacher or to books. The difficulty with both is similar, for neither can the knowledge of one person nor the compass of a single book cover all the points that crop up in the minds of the many inquirers, each pursuing his own line of interest. The earlier pages of this article must be taken as furnishing simply a skeleton of zoological science. The worker who would clothe these bare bones of essential facts with the rich drapings of knowledge dependent on associated observations, experiments, arguments, and controversies, must search in other fields. In the pages that follow some guidance is given to such enthusiasts, each according to his kind, so that along any particular line of investigation the inquirer, instead of floundering amongst masses of unknown books, may place his hand directly upon such as will further his investigation.

I. Natural History for the General Reader.—The greater number of people look upon natural history as a mild interest rather than as a definite hobby. For such the casual observations which enliven a country walk or season a summer holiday form the acme of zoological ambition. Nevertheless the fact casually observed forms part of the general scheme of life and fills its own definite place in the interpretation of a life-story, or in the march of the season's activities. To place the fact in its general relationship may be the work of many continuous observations, and this method of testing from experience is always the best; yet the difficulties involved are often insurmountable, and the inquirer is compelled to turn to the observations of naturalists better endowed than he with opportunity, leisure, or perseverance.

(*a*) DISCURSIVE NATURAL HISTORY.—There are many pleasant paths along which such a seeker after truth may travel, his own inclination being the finger-post which indicates the most suitable way. Thus guided, he may browse amongst the nature studies of men whose close contact with living things is apparent in their every page, and who nevertheless weave a romance around the bare facts of life. Most famous of these is Gilbert White, whose *Natural History and Antiquities of Selborne in the County of Southampton* (1788), contains a series of letters dealing quaintly with the creatures of his own parish. One seems to catch the essence of the open air in the breezy descriptions of Richard Jefferies (1848–1887) in his *The Gamekeeper at Home, Wild Life in a Southern County, The Amateur Poacher*, and other works; or in the graceful moralisings on nature of Henry Thoreau (1817–1862). Such discursive books are legion, and only a few which may stand as types need be indicated: such are Charles Kingsley's *Water Babies*; P. H. Gosse's *Romance of Natural History*; Grant Allen's *Vignettes from Nature; The Evolutionist at Large, Falling in Love*; P. Robinson's treatment of myth and poets' fancies in *The Poets' Birds, The Poets' Beasts, The Poets' Insects*; the interpretive works of W. J. Long—*Beasts of the Field, Fowls of the Air,*

School of the Woods, &c.; the more scientific treatment of J. Arthur Thomson in his charming and comprehensive *The Wonder of Life*, or of E. Ray Lankester in his series of *Essays from an Easy Chair*.

(*b*) SEASONAL NATURAL HISTORY. — The casual observer or the beginner may, however, desire that some more evident thread should link together the daily facts for him. He could not do better in such a case than take nature herself for guide and, following her ways, trace the ebb and flow of life throughout the year. Assistance may be had from such books as: L. C. Miall's *Round the Year;* Herbert Maxwell's *Memories of the Months;* J. Arthur Thomson's excellent *Natural History of the Year*, or his suggestive and more recent *Biology of the Seasons;* and the charmingly written and illustrated volumes on *The English Year—Spring, Summer*, and *Autumn and Winter*, by Beach Thomas and Collett, in three volumes, just published.

(*c*) NATURALIST TRAVELLERS.—Records of travel in foreign lands and seas form another gathering point of general interest, the narrative of personal encounter with unknown or rare animals having an appeal unfortunately denied to new facts concerning familiar animals.

Typical examples of such works are: A. R. Wallace's *Malay Archipelago, Tropical Nature*, and *Island Life;* H. W. Bates's *Naturalist on the Amazons;* S. J. Hickson's *A Naturalist in North Celebes;* C. M. Woodford's *Naturalist among the Head-hunters;* S. W. Baker's *Wild Beasts and their Ways; Reminiscences of Europe, Asia, Africa, and America;* W. H. Hudson's *The Naturalist in La Plata;* or, dealing in particular with travel by sea, Charles Darwin's *Voyage of the "Beagle,"* Wyville Thomson's *The Depths of the Sea*, H. N. Mosley's *Naturalist on the "Challenger,"* and A. Alcock's *A Naturalist in Indian Seas*.

(*d*) HOLIDAY BOOKS.—Still another path to knowledge lies before the general observer. It is for many opened up only once a year, and just for the few short days of the summer holiday. Then new facts and new animals crop up with wondrous frequency, stimulate the desire for names and information, and cry out for some book which will solve all problems. Such, perhaps fortunately, is not to be found, but some holiday books are suggested hereafter in the section dealing with "Books for Collectors."

II. General Zoology.—To the serious student anxious to get to grips with his subject, to gain as rapidly and effectively as may be a bird's-eye view of the science of zoology in its many ramifications, the guidance so far given must seem the veriest dilettantism. He requires a book wholly devoted to the subject, unhampered by unnecessary detail which might lead him from the main path or might befog his perception of the guiding truths; wherein, moreover, the often slip-shod narration of the casual observer is replaced by the reasoned arrangement of the scientist. It is not implied that these requirements can be met only by a work of dry-as-dust style, though some, with Grant Allen, "prefer their science and champagne as dry as they can get them." Therefore for the convenience of readers who from different starting points, and with different objects in view, wish to survey the field of general zoology, we have separated this division into three sections: the first, or *Introductory*, containing books which cover the field in simple and readable fashion; the second, or *Text-book* section, containing a selection of formal text-books which present their matter without waste of words; and the third, or *Reference* section, including more cumbrous treatises which cover the whole field in a manner so complete as to render their assimilation as a whole impossible, but which must nevertheless be referred to in advanced general study.

(*a*) INTRODUCTIONS TO ZOOLOGY.—Amongst the most valuable, because most simple, of the elementary books are: A. B. Buckley's *Life and Her Children*, and *Winners in Life's Race*. The former deals with backboneless or invertebrate animals, the latter with vertebrates, so that taken together they give a conspectus of the whole animal kingdom eminently suited for youthful beginners. J. Arthur Thomson's *The Study of Animal Life* pays special attention to the great general truths which peep out in the lives of animals, while *Zoology, an Elementary Text-book*, by A. E. Shipley and E. W. MacBride, is in great part devoted to the discussion of the animals themselves and their parts.

Apart from Thomson's *Study*, abovementioned, several works lay special stress on the life activities of animals. Amongst such may be taken as typical: C. Lloyd Morgan's *Animal Biology;* T. Jeffrey Parker's *Lessons in Elementary Biology;* F. W. Gamble's *Animal Life;* J. F. Abbott's *The Elementary Principles of General Biology;* P. Chalmers Mitchell's *Childhood of Animals;* R. Groos's *The Play of Animals;* W. P. Pycraft's *The Courtship of Animals*.

(*b*) TEXT-BOOKS.—Under this heading are included formal expositions of zoological science, such as are prescribed for the ordinary degree pass examinations in our universities and similar institutions. It must be kept in mind, however, that a knowledge acquired from reading alone, unsupplemented by actual observation and experience of the main types of animal life, is certain to fall short even of moderate requirements. To rectify the tendency to bookish zoology, students should consult and make use of the guides to practical zoology mentioned below in section (*d*).

In *Zoology*, by A. S. Packard, hints are given

as to practical work to accompany the reading of the text; the *Text-book of Zoology*, of T. J. Parker and W. A. Haswell, is a clearly expressed work in two volumes. J. Arthur Thomson's *Outlines of Zoology* (5th ed.), contains the essential facts well arranged and compressed into a single volume. It is a favourite text-book. While for the student who would master the subject in greater detail is Adam Sedgwick's *A Student's Text-book of Zoology*, in three volumes, a work of great value, wherein the latest knowledge concerning animal structure and general habits has been embodied, and special attention has been paid to the enumeration of genera, and to their relegation to families and more comprehensive groups.

(*c*) Books of Reference to General Zoology.—Herein two types of works fall—one set more fitted for the student, the other for the general reader. The first comprises such volumes as form in reality glorified text-books, and includes: *The Cambridge Natural History*, edited by S. F. Harmer and A. E. Shipley, the ten volumes of which form a readable account covering the whole animal kingdom in considerable detail. More special in treatment is E. Ray Lankester's *A Treatise on Zoology*, still incomplete, in spite of the publication of many volumes. It is furnished with moderately full bibliographies. In these two fine series the description of each section of the animal kingdom has been contributed by an expert specially qualified, and the volumes, each of which deals with a definite group or groups, can be purchased separately. Reference should also be made to the zoological articles in the *Encyclopædia Britannica*. Foreign treatises with a somewhat similar bearing are: *Traité de Zoologie Concrète*, edited by Yves Delage and E. Hérouard, a work unfortunately incomplete in spite of the publication of five volumes, but distinguished by the clearness of its description and diagrammatic illustrations, by its attempt to indicate the leading character of each genus known, and by its bibliographies; and Bronn's *Klassen und Ordnungen des Tierreichs*, a huge work commenced in 1859, parts of which are still being issued. Perhaps one ought to mention here also, although its appeal is rather to the expert worker at defined groups, the invaluable and monumental *Das Tierreich*, edited by F. E. Schulze, in course of publication by Friedlander & Son, in the parts of which are to be found specialist accounts of small sections of the animal kingdom, with descriptions of all the species recognised.

In addition to the student's volumes mentioned above are a number of reference works whose appeal is more to the general reader. In them less attention is paid to minute structural detail and more to habits and the interesting facts of life, while a greater proportion of space is devoted to the more "popular" groups of animals. Amongst such are *The Royal Natural History* (6 vols.), edited by R. Lydekker; *The Riverside Natural History* (6 vols.), edited by J. S. Kingsley; Cassell's *Natural History* (6 vols.), edited by P. Martin Duncan; and Brehm's *Thierleben*, an exceedingly useful German work in ten volumes in the more recent editions. These works view the subject from a systematic point of view, treating each group by itself in sequence of natural order, beginning with the highest and ending with the lowest or *vice versa*. But this method is avoided in *The Natural History of Animals* (8 half volumes) by J. R. Ainsworth Davis, where a classification of activities rather than a classification of animals is adopted; and in the *Book of Nature Study*, edited by J. Bretland Farmer, which aims particularly at supplying information and guidance to teachers of nature study.

(*d*) Guides to Practical Work.—It has already been insisted upon that the *reading* of zoological works is only half a training, which must be supplemented by actual observation in the open, and by the examination and dissection of the structures of at any rate the outstanding types of the animal world. The help of an expert teacher is in the latter case little short of indispensable, but some progress can be made by following the directions of such books as are here mentioned. Perhaps it will meliorate the disappointment which is almost certain to cloud the beginners early efforts, to promise that dissection is not an easy thing: long practice is necessary before the hand gains its cunning, the parts shown and named so clearly in diagrams appear never to be in place in the actual dissection, and, unfortunately, many new and cumbrous names must be memorised. Perhaps, since the would-be practical student must break himself in, as it were, to new methods and close attentive work, he had better, with this end in view, begin with one of the many monographs which describe a single creature with minute thoroughness. Such may be exemplified by *The Cockroach*, by L. C. Miall and A. Denny; *The Frog, an Introduction to Anatomy and Histology*, by A. Milnes Marshall; or any one of the excellent volumes on marine types, published at the instance of the Liverpool Marine Biology Committee, and including treatises on Ascidia (sea squirt), Cardium (cockle), Echinus (sea urchin), Plaice, Patella (limpet), Arenicola (lob worm), Cancer (edible crab), and several others. Other introductory monographs are T. H. Huxley's *The Crayfish*; Wilder and Gage's *Anatomical Technology as applied to the Domestic Cat*; and Mivart's *The Frog*, and *The Cat, an Introduction to the Study of Backboned Animals, especially Mammals*. The recognition and mastery of the structures described and figured in any one of these volumes will put the student in position easily to carry out an elementary

course of practical work on familiar types of animals. For guidance he may lean upon Huxley and Martin's *A Course of Elementary Instruction in Practical Biology* (revised edition); Milnes Marshall and Hurst's *A Course of Practical Zoology;* T. J. Parker's *Zootomy;* with the assistance, perhaps, of the very helpful illustrations in G. B. Howes's *Atlas of Practical Elementary Biology*, or in W. R. Smith and J. S. Norwell's *Illustrations of Zoology.* Advanced students anxious to tackle the finer problems of structure by means of thin sections for examination by microscope will find useful guides to the killing, preserving, section-cutting, staining, and mounting of various types of animals and tissues in C. O. Whitman's *Methods of Research in Microscopical Anatomy and Embryology*, or in A. B. Lee's invaluable *Microtomists' Vade-Mecum* (latest edition).

III. Collectors' Books.—Of the paths which lead to the naturalist's highest goal, a wide sympathy with nature, none is more often trodden than the narrow way of the collector. The instinct of gathering is common to child and adult alike, the miscellaneous gathering of the one soon leading to the discriminate collecting of the other. A few hints as to the books best adapted for collectors of different degrees may settle an occasional difficulty or help to brighten a holiday ramble. Perhaps we should add that we use the description "collector" in a wide sense to include the naturalist who wishes simply to discover the names of the creatures he observes, as well as he who, in addition, desires to hoard them. For the former, with his more catholic tastes, the titles of a few general *holiday* books are given.

(*a*) HOLIDAY BOOKS.—The country holiday demands such books as *The Out-door World, or Young Collector's Handbook*, by W. Furneaux, or *Life in Ponds and Streams*, by the same author; J. G. Wood's *Common Objects of the Country;* J. E. Taylor's *Half Hours in Green Lanes*, or one of the many similar books which have appeared of recent years.

The seaside holiday is well supplied with guidance: Charles Kingsley's *Glaucus;* P. H. Gosse's *Naturalist's Rambles in Devonshire*, or for more advanced observers, his *Manual of Marine Zoology* (2 vols.); J. E. Taylor's *Half Hours at the Sea Shore;* G. A. and C. L. B Boulenger's *Animal Life by the Sea-Shore;* or, perhaps the most generally useful of all, Marion Newbigin's *Life by the Seashore.*

(*b*) BOOKS DEALING WITH SPECIAL GROUPS OF ANIMALS.—Here again, it will be noticed, we deal with the collector in a broad sense, in the opinion that he who simply aims at recognising and naming the members of a group of animals misses half the interest which that group ought to hold for him. There is a special fascination for many in labelling a specimen with its specific name, but the wider issues of general relationship within the group and within the larger world of animals in general, the problems of life-history, life adaptation, life association, and the like, ought not to be missed; for their study widens the horizon and adds infinitely to the intellectual pleasure of observation. We would recommend, therefore, that the naturalist who determines to master the members of a limited group of animals should read, either the chapter dealing with the group selected in one of the reference books already referred to, such as the *The Cambridge Natural History*, or one of the general books mentioned in the sections that follow. At least one general book, where such exists, will be mentioned at the beginning of each section, but owing to lack of space and the greatness of the subject it is necessary to confine the special books almost entirely to those which deal with the British fauna, preference being given where possible to such as are most clearly written and illustrated, and are sold at a reasonable price—such, indeed, as are best suited to the young collector who finds that the holiday books are not sufficient for his needs.

PROTOZOA: E. A. Minchin, *An Introduction to the Study of Protozoa*, with good bibliography; F. Chapman, *The Foraminifera;* J. Cash and J. Hopkinson's *The British Freshwater Rhizopoda and Heliozoa* (2 vols.).

SPONGES: Bowerbank's *Monograph of British Spongiadæ* (4 vols.); no elementary work.

CŒLENTERATES: Landsborough's *Popular History of British Zoophytes;* Hincks's *British Hydroid Zoophytes* (2 vols.); Gosse's *History of British Sea Anemones and Corals.* As regards Britain many of the Cœlenterate groups have not been dealt with, but the anxious inquirer will find all the jelly-fishes, large and small, in A. G. Mayer's *Medusæ of the World* (3 vols.).

WORMS: No comprehensive books; G. Johnston's *Catalogue of British non-parasitical Worms* is out of date; earthworms are dealt with generally in F. E. Beddard's *Earthworms and their Allies*, and in mystifying detail in his large *Monograph of Oligochæta.* For marine worms see W. C. M'Intosh's *British Annelids* (4 vols., still incomplete).

POLYZOA: Some described in Landsborough's *Popular History of British Zoophytes;* Hincks's *British Marine Polyzoa* (2 vols.).

ECHINODERMATA (Sea-urchins, Starfishes, and their relatives): Forbes's *British Starfishes;* Jeffrey Bell's *Catalogue of British Echinoderms in the British Museum.*

MOLLUSCA: T. B. Woodward's *Life of the Mollusca;* Ed. Step's *Shell Life;* Jeffrey's *British Conchology* (4 vols.); Taylor's *British Land and Freshwater Mollusca* (still incomplete); Rimmer's *Shells of the British Islands, Land and Freshwater.*

CRUSTACEA: T. R. R. Stebbing's *History of*

Crustacea; W. T. Calman's *Life of Crustacea;* White's *Popular History of British Crustacea;* Bell's *History of the British Stalk-eyed Crustacea,* treats of crabs, lobsters, and the higher forms, Bate and Westwood's *History of the British Sessile-eyed Crustacea,* of most of the lower forms.

SPIDERS: Blackwall's *Spiders of Great Britain and Ireland;* and O. Pickard-Cambridge's *Spiders of Dorset.*

INSECTS: P. Martin Duncan's *The Transformations of Insects;* H. Bastin's *Insects, their Life-histories and Habits;* J. H. Fabre's *Social Life in the Insect World,* and other works; L. C. Miall's *Natural History of Aquatic Insects;* Packard's *Text-book of Entomology;* Kellogg's *American Insects;* H. M. Lefroy's *Indian Insect Life;* E. A. Ormerod's *Manual of Injurious Insects;* A. T. Gillander's *Forest Entomology;* Miss Steveley's *British Insects;* or, for individual groups—W. J. Holland's *The Butterfly Book;* South's *Butterflies of the British Isles,* and *Moths of the British Isles;* W. E. Kirby's *Butterflies and Moths of the United Kingdom;* or the monographic *Lepidoptera of the British Isles,* by C. G. Barrett (11 vols.); E. Saunders's *Wild Bees, Wasps, and Ants;* or his more comprehensive *British Hymenoptera Aculeata;* Hofmann and Kirby's *The Young Beetle-collector's Handbook;* or Canon Fowler's complete *Coleoptera of the British Isles* (6 vols.); E. Saunders's *Hemiptera Heteroptera of the British Islands,* and J. Edwards's *Hemiptera Homoptera of the British Islands;* W. J. Lucas's *British Dragonflies;* F. V. Theobald's *An Account of British Flies (Diptera);* J. Lubbock's *Monograph of the Collembola and Thysanura* (springtails, &c.).

As books on the various classes of Vertebrates are very numerous the following is a much curtailed summary. A useful work for the young collector is F. G. Aflalo's *Natural History (Vertebrates) of the British Islands.* Almost every group is dealt with from a general point of view in separate volumes of the *Cambridge Natural History,* and Lankester's *Treatise of Zoology.*

FISHES: A. Günther's *An Introduction to the Study of Fishes;* D. Starr Jordan's *A Guide to the Study of Fishes* (2 vols.); F. Day's *The Fishes of Great Britain and Ireland* (2 vols.); and C. Tate Regan's *The Freshwater Fishes of the British Isles.*

AMPHIBIANS (BATRACHIANS) AND REPTILES: G. A. Boulenger's *Tailless Batrachians of Europe,* and *The Snakes of Europe;* R. L. Ditmars's *Reptiles of the World;* T. Bell's *A History of British Reptiles [and Batrachians];* M. C. Cooke's *Our Reptiles and Batrachians.*

BIRDS: W. P. Pycraft's *A History of Birds;* St. G. Mivart's *Birds: the Elements of Ornithology;* F. E. Beddard's *The Structure and Classification of Birds;* Johns's *British Birds;* H. Saunders's *An Illustrated Manual of British Birds;* or one of the many-volumed and expensively illustrated works, such as Lord Lilford's *Birds of the British Islands* (7 vols), or Kirkman's *The British Bird Book* (4 vols.).

MAMMALS: W. H. Flower and R. Lydekker's *An Introduction to the Study of Mammals living and extinct;* F. Finn's *Wild Beasts of the World;* T. Bell's *A History of British Quadrupeds;* R. Lydekker's *A Handbook to the British Mammalia;* or one of the exceeding detailed, lavishly illustrated, and expensive works such as J. G. Millais's *The Mammals of Great Britain and Ireland* (3 vols); or G. E. H. Barrett-Hamilton's *A History of British Mammals,* in many volumes, still incomplete.

IV. **The Geographical Distribution of Animals.**—Any article or book which deals with the creatures of even a single region bears on the subject of the geographical distribution of animals. Such are far too numerous to mention, and so the following titles are limited to a few works which give a general conspectus of distribution, indicate its guiding lines, and show how the present distribution of animal life gives a clue to the genealogy of animals and reveals a constantly changing relationship between the areas of land and sea. The most recent and most simple treatment is to be found in M. I. Newbigin's *Animal Geography.* More pretentious works are: A. Heilprin's *The Geographical and Geological Distribution of Animals;* F. E. Beddard's *A Text-book of Zoogeography;* A. R. Wallace's standard volumes, *The Geographical Distribution of Animals* (2 vols.); and Bartholomew, Clarke, and Grimshaw's valuable *Atlas of Zoogeography,* with descriptive text and copious bibliography. More special are R. F. Sharff's *The History of the European Fauna,* and *European Animals: their Geological History and Geographical Distribution;* W. L. and P. L. Sclater's *The Geography of Mammals;* and R. Lydekker's *A Geographical History of Mammals.*

V. **The Animal Body—its Structures, Functions, Development, &c.**—We think it advisable to segregate here a few books which, applied to a special theme, treat it in a manner which encourages a broad understanding of the special subject. The student, bewildered in the mazes of a zoological text-book, wishes to gather up definite threads—wishes, for example, to trace connectedly the changes undergone in the structure of the heart or any other organ in progressive groups of animals, to discover by what steps the simple functions of Amœba become split up, specialised, and made more efficient in the higher animals, or to learn the secrets of the growth and development of animals from the very egg. So to learn he must leave the direct path of general zoology and enter the great side tracks of those specialised sciences which seem more and more to become self-centred and self-contained.

(*a*) STRUCTURES OF ANIMALS (COMPARATIVE

Anatomy).—G. Gegenbaur's *Elements of Comparative Anatomy;* A. Lang's *Text-book of Comparative Anatomy,* which treats only of the invertebrate animals (2 vols.); R. Owen's *Comparative Anatomy of Vertebrate Animals* (3 vols.); and R. Wiedersheim's *Comparative Anatomy of Vertebrata.* Reynold's *The Vertebrate Skeleton,* or W. H. Flower's *An Introduction to the Osteology of the Mammalia* (later editions), are more special works well worth consulting, as also are G. A. Peake's *Notes on Dental Anatomy* and R. Owen's *Odontography; or a Treatise on the Comparative Anatomy of the Teeth* (2 vols.).

(*b*) Animal Functions (Comparative Physiology.—F. J. Bell's *Comparative Anatomy and Physiology;* A. B. Griffith's *Comparative Physiology;* Carpenter's *Principles of Physiology.* Here may also be included Thomson and Geddes's *Evolution of Sex.*

(*c*) The Early Development of Animals (Comparative Embryology).—A. C. Haddon's *Introduction to the Study of Embryology;* F. M. Balfour's *Comparative Embryology* (2 vols.); A. Milnes Marshall's *Vertebrate Embryology;* and W. Heape's *Text-book of Comparative Embryology,* of which an invaluable vol. 1, *Invertebrata,* by E. W. MacBride, has just appeared.

(*d*) The Mind of Animals (Comparative Psychology).—G. J. Romanes's *Animal Intelligence;* and C. Lloyd Morgan's *Introduction to Comparative Psychology, Animal Life and Intelligence,* and *Habit and Instinct.*

VI. Generalised Views of Animal Life: Laws, Theories, Hypotheses, &c.—No view of animal life approaches completeness, no matter how many the details of physical structure it has encompassed, if the facts mastered remain simply isolated items of information. Life is a continuity, a steady unbroken flow, and it is only by rising above the details that one can see the maze of facts in their proper perspective, and gain a wide sweep of the unity that underlies all. It is the aim of Philosophic Zoology to set us on this vantage point by treating in a general way some of the great "laws" of nature. The titles of some helpful books are here grouped in a few broad sections:

(*a*) General.—A useful recent summary is R. H. Lock's *Recent Progress in the Study of Variation, Heredity, and Evolution;* and E. D. Cope's *The Primary Factors of Organic Evolution.*

(*b*) Variation.—H. M. Vernon's *Variation in Animals and Plants;* K. Semper's *The Natural Conditions of Existence as they affect Animal Life;* Charles Darwin's *Variation of Animals and Plants under Domestication;* and a work valuable for records of variation and a masterly introduction, W. Bateson's *Materials for the Study of Variation.*

(*c*) Heredity.—J. Arthur Thomson's *Heredity;* G. Archdall Reid's *Principles of Heredity;* F. Galton's *Natural Inheritance;* and confined to special aspects—W. Bateson's *Mendel's Principles of Heredity;* and R. C. Punnett's *Mendelism.*

(*d*) Evolution.—Charles Darwin's *Origin of Species;* S. Butler's *Evolution: Old and New;* F. W. Headley's *Life and Evolution,* and *Problems of Evolution;* A. R. Wallace's *Darwinism;* T. H. Morgan's *Evolution and Adaptation;* E. B. Poulton's *Essays on Evolution;* A. Weismann's *The Evolution Theory* (2 vols.) translated by J. Arthur Thomson and Margaret R. Thomson; and less comprehensive, E. Ray Lankester's *The Kingdom of Man,* and from the point of view of human society, C. W. Saleeby's *Parenthood and Race Culture.*

James Ritchie, M.A., D.Sc.

HUMAN PHYSIOLOGY AND ANATOMY

THE BRICKS OF THE BODY

All forms of animal life, from the lowest—a mere speck of formless jelly, up to man, the "roof and crown of things," are constructed on the same general principles, and obedient to the same fundamental laws. They all feed, grow, and reproduce. In the one case these functions are performed with the simplest possible apparatus; in the other, the apparatus is highly complex.

To begin with one of the lowest forms of animal life—the *amœba*. The amœba, a single cell floating in sea-water, in common with all other animals, is composed of an essential "life-stuff"—*protoplasm*, similar in appearance to the "white" of an egg, and defined by Huxley as the "physical basis of life," as through its medium all the phenomena of life are manifested. There is no protoplasm apart from life, and no life without protoplasm. It is impossible to analyse it, for it is a *living* substance, and no philosopher has, as yet, been able to tell us what life is. When dead, it yields up nitrogen, oxygen, carbon, hydrogen, sulphur, and phosphorus. By virtue of this protoplasm the amœba is endowed with many complex activities; for example, it generates heat, it wastes and repairs, it moves about, it reacts to external stimuli, it reproduces its kind. It thus expends energy, and the expenditure involves renewal. How is this renewal effected—what winds up the vital clock? The answer is Food—and we use this term in the broad sense to comprise air, water, and ordinary solid food. As we trace the animal creation through its long series of evolutionary changes, from the amœba upwards, we find that instead of a single cell, millions of cells go to compose the individual, the cells being arranged in various groups called *organs*, each organ subserving a particular function. Thus we have the organs for digestion (alimentary tract), respiration (lungs), circulation (heart and blood-vessels), for the generation and transmission of nerve-impulses (nervous system), and so on. By means of these various organs there is brought about what has been termed the *physiological division of labour*, every group of cells having its allotted task—the simple and homogeneous having become the complex and heterogeneous.

The organic unit, then, is the cell, and it bears the same relation to the body that the brick does to the house.

If we take a typical cell and examine it under the microscope, we find its structure to be as follows: a harder outer part—the *cell-wall*; a jelly-like material (protoplasm) filling the inside and constituting the *cell-body*. Occupying the centre is the most highly specialised part of the cell—the *nucleus* or kernel. The cell, then, is a unit of protoplasm consisting of a cell-wall, cell-body, and nucleus. The nucleus contains a substance called *chromatin*. The nucleus appears to be the actual "brains" of the cell—presiding over and inspiring its many activities. If a cell loses its nucleus, it ceases to grow, and cannot multiply.

Cell-multiplication.—The nucleus divides first, then the cell-body. We have now two daughter-cells, each with its own nucleus. The daughter-cells then separate, growing into adult cells similar to their parent. Thus, every cell is derived from a pre-existing cell, every nucleus from a pre-existing nucleus.

From the biologic point of view, the body is an organised cell-republic, each individual cell, though living its own life like the amœba, yet at the same time co-operating with all the other cells for the common good of the body as a whole. The cells composing the different organs of the body are moulded into different forms in accordance with the different functions they are called upon to perform. Thus, in the case of muscle, the cells are spindle-shaped; in the case of a gland, the cells are cubical.

In speaking of the collective group of cells composing an organ the term *tissue* is employed. Thus, the muscles are composed of muscular tissue; the bones of osseous tissue; the glands of gland tissue; the nervous system of nerve tissue. Not only does each tissue possess distinct structural peculiarities, but it also possesses distinct functional properties. For example, muscle is characterised by its contractility; bone by its hardness and strength; nerve-cells by their power of generating impulses, nerves by their power of conducting impulses; glands by their power of secreting juices, and so on. The fabric of the body, then, is not of uniform texture throughout, but is composed of a variety of separate tissues, differing from one another in minute structure in adaptation to the performance of special functions.

The study, by the aid of the microscope, of the minute structure of the tissues, is known as *Histology*.

Cells range in size from 0·1 to 0·001 millimetre,

that is, approximately, from $\frac{1}{250}$th to $\frac{1}{25000}$th of an inch in diameter. The unit of measurement is taken to be 0·001 millimetre, called technically a *micro-millimetre* (= $\frac{1}{1000}$th part of a millimetre = $\frac{1}{25000}$th of an inch), and expressed by the Greek letter μ. Thus, the average size of the red blood corpuscle is 7·5 μ, which is equivalent to about $\frac{1}{3200}$th of an inch.

There is a special kind of tissue that performs many important functions in the service of the body. It is called *Epithelium*. It covers the surface of the body, lines the whole length of the alimentary canal and respiratory passages, as well as other parts. On the outside of the body it is known as *Epidermis*; on the inside of the body it constitutes the *Mucous Membrane*. Hairs and nails are built up of modified epithelial cells. Furthermore, it dips down in places to form "*glands*." Here it is necessary to explain the nature of a gland. In its simplest form, a gland consists of a small tube, or series of tubes, lined by epithelium, outside which are abundant blood-vessels. At its lower end the tube is blind; at its other end, it opens on to a surface by a *duct*. The essential part of the gland is the epithelium, for upon it falls the duty of taking from the blood a certain something, which is either useful or useless to the body. In the former case, we call it a *secreting* gland; in the latter, an *excreting* gland. The mammary gland is an example of a secreting gland; it takes raw materials from the blood and manufactures them into milk. The kidney is an example of an excreting gland, for it filters from the blood certain waste-products (urea, uric acid, &c.) which would be harmful if retained in the system.

The Cell and its Nourishment.—All the cells of the body, though closely packed, yet in a sense may be said to live in a kind of sea-water, inasmuch as each cell is surrounded by a salty fluid which contains oxygen and food-stuffs. Just as the amœba takes from the water in which it lives oxygen and food-stuffs, discharging to it the waste-products of its body, so does each cell of the human body take from the surrounding fluid oxygen and food-stuffs and discharge to it its waste-products.

Food.—This fluid, in which all the cells of the body lie bathed, is called *Lymph*. The next question to discuss is the origin of this lymph, but before doing so it is necessary to say something about "Food."

Taken in its broadest sense, food includes oxygen, liquids, and solids. The cells of the body must have a continuous supply of oxygen, water, proteins, sugars, fats, and salts. The oxygen enters through the lungs and is absorbed into the blood. The other substances are passed through the mouth into the alimentary canal and, after digestion, enter the blood. The blood is pumped by the heart into a series of tubes known as arteries. These decrease in diameter until they become of very minute size. They are then known as capillaries. From the capillaries the nutrient materials are always oozing out into the lymph, which forms a vast irrigation system between all the cells of the body.

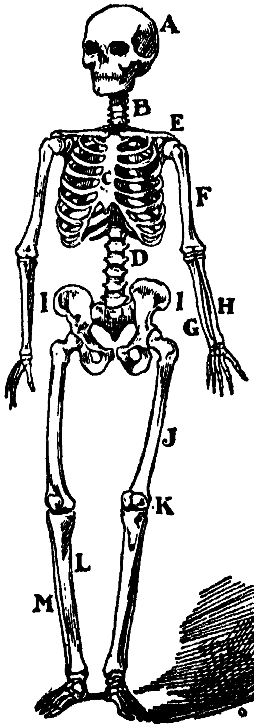
The lymph, then, is a medium of exchange between the blood and the tissues. It feeds the tissues and receives from them their waste-products. It comes from the blood, is always on the move, and, as we shall later on see, ultimately returns to the blood.

Man's body, then, is built up of different organs or systems, so arranged and correlated as to constitute an organic whole.

Thus, the skin, hair, and nails constitute the integumentary system; the muscles, the muscular system; the bones, the osseous system; the heart and blood-vessels, the vascular system; the lungs, the respiratory system; the stomach, intestines, and accessory glands, the alimentary system; the brain, spinal cord, and nerves, the nervous system; the kidneys and bladder, the urinary system; and the generative organs, the reproductive system.

For descriptive purposes we may consider the body as composed of an *axial* part consisting of head, neck, chest, abdomen, and pelvis; and an *appendicular* part, the limbs.

In the head is lodged the brain, continuous with the spinal cord below. Passing down the neck are the windpipe (*trachea*) and the gullet (*œsophagus*). Within the chest (*thorax*) are the heart and lungs and continuation of the œsophagus. In the abdomen and pelvis are the stomach, intestines, liver, and other accessory glands, with the organs concerned in the urinary and reproductive functions.



A skull (*q.v.*), made up of 22 bones; *B*, cervical vertebræ; *C*, sternum or breast bone; *D*, lumbar vertebræ; *E*, clavicle or collar bone; *F*, humerus; *G*, ulna; *H*, radius; *I*, pelvis; *J*, femur; *K*, patella; *L*, tibia; *M*, fibula.

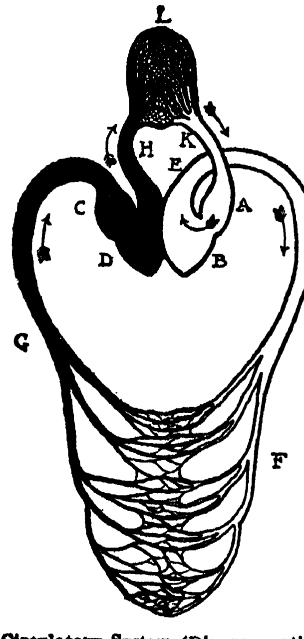
THE SKELETON

The skeleton is the supporting framework which sustains the softer parts of the body. The number of bones composing it vary at different periods of life. In the adult there are about 200.

The Muscular System.—The muscles constitute the "flesh" of the body, and compose about half its bulk. Besides ordinary walking, &c., by means of muscle, the circulation of the blood is carried on, and respiration and movements of the stomach and intestines are effected. There are about 400 muscles altogether, and each is brought into relation with the nervous system by a *nerve*. Most of the muscles are under the influence of the will, and are then called *voluntary*. Those not under such influence are called involuntary, good examples of which are the heart, stomach, and intestines.

THE BLOOD AND THE ORGANS OF CIRCULATION

The blood, distributed in a ceaseless flow by the pumping action of the heart, is the medium by which nutrient material—oxygen, water, proteins, carbohydrates, fats, and salts—are conveyed to the various cells of the body. It consists of a fluid—the *liquor sanguinis*, in which float solid particles—the *corpuscles*. These



Circulatory System (Diagrammatic).

The arrows indicate the direction of the blood flow, from the lungs (*L*) by the pulmonary veins (*K*) to the left auricle (*A*) and left ventricle (*B*) of the heart, through the aorta (*E*) to the arteries and capillaries of the body (*F*); from the capillaries and veins of the body by the great veins (*G*) to the right auricle (*C*), thence to the right ventricle (*D*) and by the pulmonary artery (*H*) back to the lungs.

latter are of two kinds: the *red* and the *white*. The red corpuscles carry oxygen, taking it up from the air in the lungs and passing it on to the body-cells. The function of the white corpuscles is to act as scavengers, *i.e.* to keep the blood free of microbes which they hunt, seize, and destroy. For this reason Metchnikoff has designated them *phagocytes* (Greek, *phagein*, to eat). "It is the phagocyte," he says, "which delivers us from our enemies. Sometimes the phagocytes devour at one swoop whole masses of bacteria."

In addition to conveying nutrient material, the liquor sanguinis carries the waste-products (carbonic acid and urea) derived from the body-cells and delivers them up to the eliminating organs—the lungs, kidneys, and skin.

The blood is contained in a series of tubes (blood-vessels) connected with a central pump—the heart. The heart and blood-vessels together constitute the *vascular system*. The vessels which carry the blood from the heart are called *arteries*; those which convey it back to the heart are called *veins*. The arteries and veins communicate with one another through the medium of a network of extremely minute vessels—the *capillaries*. The arteries contain the pure or arterial blood, which as it traverses the capillaries parts with some of its constituents (oxygen, water, and other food-stuffs) which, leaking through their walls, nourish the body-cells. At the same time, waste-products (carbonic acid, urea, &c.) enter from the tissues. The blood in the capillaries, then, delivers food-stuffs to the body-cells and receives from them waste-products. The blood now flows back to the heart as impure or venous blood.

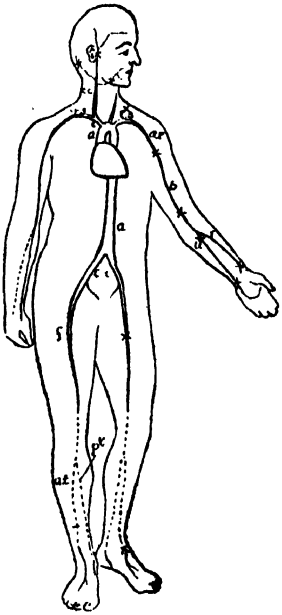
The *Heart* is a hollow muscle lodged in the thorax between the two lungs. It is divided by a partition into a right and left half, each half being subdivided by a kind of movable door or *valve*. The part above the valve is the *auricle*, and the part below the valve is the *ventricle*. So there are four chambers in the heart, a right auricle and ventricle, and a left auricle and ventricle. The valves are so arranged as to open in one direction only, and to close in the other, this arrangement permitting the blood to enter from auricle to ventricle, but not from ventricle to auricle.

The different parts of the heart contract in a definite succession and at regular intervals.

Beginning with the right side of the heart; the course of the circulation is as follows:

The right auricle receives the impure or venous blood from the two big veins—the *venæ cavæ*. When full, it contracts, the blood entering the right ventricle, which, when full, in its turn contracts, driving the blood through the lungs where it is purified by parting with its carbonic acid and taking up oxygen. The pure blood now enters the left auricle, from whence it is passed into the left ventricle, from where it is driven into the big artery (aorta) which, subdividing into a series of smaller tubes, allows of its distribution all over the body. To sum

up: the impure blood charged with waste-products enters the right heart. It is then driven through the lungs and purified. It now enters the left heart from where it is driven through the arteries into the capillaries. While flowing through the capillaries it parts with its food-stuffs and becomes charged with waste-



The Main Arteries of the Body.

a, aorta; *i*, innominate; *r.s*, right subclavian; *c.c*, common carotid; *l.s*, left subclavian; *ax*, axillary *b*, brachial; *r*, radial; *u*, ulnar; *c.i*, common iliac *f*, femoral; *a.t*, anterior tibial; *p.t*, posterior tibial ×, pressure points.

products. From the capillaries it now courses through the veins which ultimately enter the right heart by two large veins—the *venæ cavæ*.

The contraction of the heart is rhythmical, that is it recurs at regular intervals.

During the time that the heart is contracting and expelling the blood into the arteries, it is said to be in *systole*; during the time it is dilating and receiving the blood from the big veins, it is said to be in *diastole*. During systole, then, the heart empties; during diastole, it fills. Systole is the time of work, diastole the time of rest. Inasmuch as diastole lasts slightly longer than systole, it has been computed that the heart sleeps about thirteen hours out of the twenty-four.

During systole, the left ventricle squeezes about 4 ounces of blood into the arteries, which, being elastic, expand to receive it. This expansion travels as a wave along the arteries, and if the finger be placed on one of them a "throb" is communicated to it. This "throb" constitutes the *pulse*. The rate of the pulse therefore represents the rate of the heart's contraction, which, in health, is about seventy times a minute.

At each beat, the heart does enough work to raise 2 lbs. one foot from the ground. It is computed that if a bicycle be ridden uphill, the gradient being 1 in 10, the length 2904 feet, and the time of the ride 3½ minutes, the extra work imposed on the heart would have raised 1½ tons one foot from the ground!

The work of the heart can be economised in many ways. If one went to bed every night at ten instead of twelve (the heart has least work to do while lying down), the heart would be saved 876,000 foot-lbs. of work a year; by lying down half an hour daily there would be an annual economy of 219,000 foot-lbs.; an hour's rest every Sunday would save 62,400 foot-lbs., and by spending every Sunday in bed instead of only sleeping eight hours the saving in the year would be 998,400 foot-lbs.

Lymph or Tissue-juice.—All the cells of the body lie bathed in lymph, the nutrient fluid that trickles out through the thin walls of the blood capillaries. After circulating round the cells the lymph passes into a series of minute tubes (the lymph capillaries) which are ultimately gathered into one large tube—the *thoracic duct*. The thoracic duct pours its contents into one of the big veins shortly before it enters the heart.

The lymph, then, is not a stationary fluid, but is constantly on the move, giving nourishment to all the cells of the body as it circulates around them, and taking from them their waste-products (carbonic acid, urea, &c.). It comes from the blood, and eventually returns to the blood.

There are, then, two circulations—one very swift, the circulation of the blood; the other very slow, the circulation of the lymph.

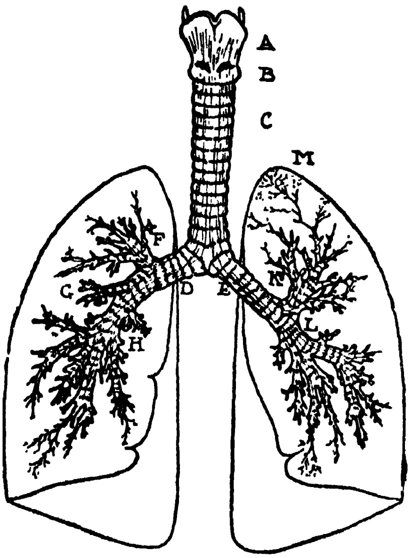
To sum up: the alimentary tube and lungs feed the blood, the blood feeds the lymph, and the lymph feeds the tissues.

THE LUNGS AND ORGANS OF RESPIRATION

All the cells of the body are continually crying out for oxygen, and without it they would speedily die. As we have seen, the red blood corpuscles are oxygen-carriers, the gas flying off from them as they course through the capillary tubes to enter the lymph which delivers it to the cells. At the same time, carbonic acid gas is given off from the cells to the lymph, which transfers it to the blood. Accordingly, there are two streams of gas continually passing in opposite directions—one from the blood to the tissues (oxygen), via the lymph; and the other from the tissues to the blood, also via the lymph. The function of the lungs is to

charge the blood with oxygen and to free it from carbonic acid.

The organs of respiration consist of an air tube called the *trachea*. The upper end of the trachea is known as the larynx, and in it lie the *vocal cords*. Below, the trachea divides into two branches, the right and left *bronchus*. Each



Respiratory System.

A, thyroid cartilage; *B*, cricoid cartilage; *C*, trachea or windpipe; *D*, right bronchus, leading to right lung; *E*, left bronchus, leading to left lung; *F*, main branch to upper lobe of right lung; *G*, main branch to middle lobe of right lung; *H*, main branch to lower lobe of right lung; *K*, main branch to upper lobe of left lung; *L*, main branch to lower lobe of left lung; *M*, terminal branches of bronchi ending in the air-cells.

bronchus divides and subdivides, the tubes getting smaller and smaller. Finally, the smallest tubes dilate into a series of minute elastic sacs, the *air-cells*, each of which is about $\frac{1}{100}$th inch in diameter. It has been calculated there are 725,000,000, air-cells, exposing a surface of about 210 square yards. Spread over the interior of the air-cells is a network of blood capillaries. Between the air in the air-cells and the blood in the capillaries a gaseous exchange takes place, oxygen passing from the air to the blood, and carbonic acid passing from the blood to the air.

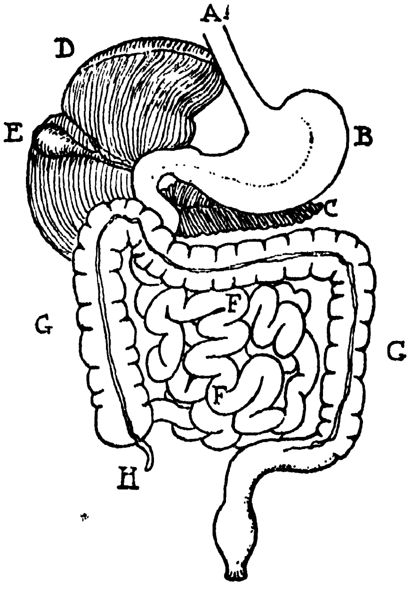
If the chest of a person be watched it will be noticed that the front and sides move rhythmically up and down. The elevation of the chest is known as *inspiration;* during it the air passes into the lungs. The depression of the chest is known as *expiration;* during it the air passes from the lungs.

Mechanism of Respiration.—The two lungs are lodged in the thorax with the heart lying between them. On either side of the thorax are the ribs, meeting at the *sternum* in front. Below is the *diaphragm*—a dome-shaped muscular partition that separates the thorax from the abdomen. During inspiration, the ribs are raised and the diaphragm depressed. In this way the chest expands, the elastic lungs are inflated, and air sucked in. During expiration the ribs and diaphragm return to their original position of rest. In this way the chest contracts, the elastic lungs are deflated and air expelled.

THE ALIMENTARY SYSTEM

The alimentary system comprises all those organs concerned in the digestion of food, viz. the alimentary canal, the liver, and pancreas. The alimentary canal is about 28 feet long, and consists of the following divisions: mouth, pharynx, œsophagus, stomach, small intestines, and large intestine.

The canal is lined throughout by epithelium, which constitutes its *mucous membrane*. Composing the main thickness of the canal, is the muscular coat which, by its contraction, causes the food to be propelled onwards. Opening on to the free surface of the mucous membrane are the orifices of thousands of minute glands whose



Digestive System.

A, œsophagus; *B*, stomach; *C*, pancreas; *D*, liver; *E*, gall bladder; *F*, small intestine; *G*, large intestine; *H*, appendix.

function it is to secrete a fluid which, acting on the food, renders it capable of being absorbed into the blood. A man takes daily into his mouth a certain quantity of solid and liquid food in the form of meat, bread, butter, water, and the like. The nutrient parts of these

various substances are absorbed into the blood, the non-nutrient parts are discharged as *fæces*. It now remains to discuss the changes which the food undergoes during its passage through the alimentary canal.

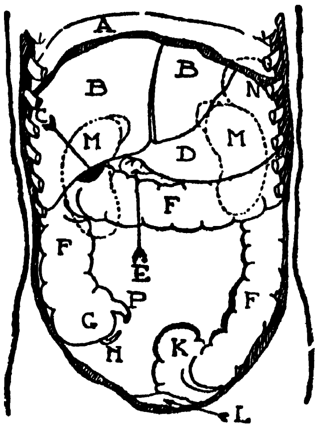
In the mouth the food is ground by the teeth (and the more thorough this is the better digestion generally) and mixed with *saliva*—a fluid secreted mainly by four large glands known as the *parotid* and the *submaxillary*. The saliva not only keeps the mouth moist, and therefore aids in articulation, but it converts the starches of the food into sugar.

The *Tonsils* are two almond-shaped bodies placed one on each side at the back of the mouth.

The *Pharynx* is the chamber behind the mouth into which open: the mouth, the œsophagus, the larynx, the nose, and the Eustachian tubes (or passages leading from the ears).

The *Œsophagus* or *Gullet* is the tube (about 9 inches in length) along which the food passes from the pharynx into the stomach. The upper part lies in the neck, and the lower part in the thorax. The remaining parts of the alimentary system are contained in the abdomen.

The Abdomen, or Belly, is the large cavity which occupies the lower part of the trunk. It is separated from the thorax above by a muscular partition, the *diaphragm*, while below it is



Abdomen, with Front Abdominal Wall (including the Ribs) and the Small Intestines removed.

A, diaphragm; *B*, liver; *C*, gall-bladder; *D*, stomach; *E*, pancreas; *F*, *F*, *F*, large intestine; *G*, cæcum; *H*, appendix; *K*, rectum; *L*, bladder; *M*, *M*, kidneys (behind); *N*, spleen (behind); *P*, junction of small with large intestine.

continuous with the pelvis. Contained within it are the liver, spleen, pancreas, kidneys, stomach, and intestines. (These various organs are technically known as *viscera*.)

The Peritoneum.—This is the delicate membrane that lines the whole interior of the abdomen. It also gives a more or less complete covering to the viscera. The former is known as the *parietal* part, the latter as the *visceral* part. Between the two is a lubricating fluid, the function of which is to permit of a certain amount of movement of the organs contained within the abdomen.

The *Stomach* is the bag-shaped portion of the alimentary canal which receives the food from the lower end of the œsophagus, and after retaining it for some time (varying with the nature of the food) discharges it into the small intestines. It occupies the left upper corner of the abdomen, and when moderately full, is about a foot in length. Its capacity is about 1¾ pints. It secretes the *gastric juice*, which converts the swallowed food into a pulpy substance resembling pea-soup, and known as *chyme*.

The *Small Intestines* are about 20 feet long, and are subdivided into three portions—the *duodenum*, *jejunum*, and *ileum*.

The *duodenum* is the commencement of the small intestines. Opening into it are the ducts of the liver and pancreas, the fluids from which put the finishing touches upon digestion, converting the chyme into a substance known as *chyle*, which is ultimately absorbed into the blood.

The *jejunum* and *ileum* form the longest part of the small intestines. The lower end of the ileum becomes continuous with the large intestines. The function of the jejunum and ileum is to absorb into the blood all the nutrient elements of the food after they have been properly prepared by complete digestion.

The *Large Intestine*, although much shorter (5 feet in length) is much larger and more capacious than the small intestine. It is disposed in the form of an arch, in the concavity of which lie the coils of the small intestine. The commencement of the large intestine is known as the *cæcum*, attached to which is a short worm-like tube—the *vermiform appendix*. This appendix is of great importance from the medical point of view on account of the fact that it often becomes infested with bacteria, which, setting up an inflammation, cause *Appendicitis*.

As the absorption into the blood of all digested food takes place from the small intestine, the large intestine appears to be useless, and from the biologic point of view the remains of an organ which at one time in our ancestral career, under the then existing circumstances, of use and value, but now become a mere "survival." Not only so, but the large intestine may at times be an actual source of danger to health, for if its contents are unduly retained (constipation), absorption into the blood of poisonous material takes place, giving rise to various symptoms of ill-health, and by lowering the vitality of the body generally, rendering it a more easy prey to attacks of bacteria, such as the tubercle bacilli, &c. &c. The non-nutrient

elements of the food are ultimately discharged from the *anus* as *fæces*.

The *Liver*, situated in the upper and right-hand side of the abdomen, is the largest gland in the body, measuring about 1 foot in its longest diameter, and weighing about 50 ounces. As can be inferred from its size, it has many important functions. It secretes *Bile*, a fluid which is, in part, useful in the digestion of fats, and in part the medium for the excretion of certain waste-products.

It serves as a warehouse for carbohydrate material, intercepting the sugars of the food, storing them up as *glycogen*, converting this again into sugar which it serves out to the blood in such amounts as the tissues require for their consumption. Another important function of the liver is to keep the blood pure. In fact, it is the great blood-purifier of the body.

The *Gall-bladder* is situated under the right side of the liver. It is pear-shaped, has a capacity of about 1½ ounces, and is a reservoir for the bile.

The *Pancreas* (Sweet-bread) is a gland, about 8 inches long, placed transversely across the upper part of the abdomen. Its secretion, which is poured out through a duct leading into the duodenum, is the most important and thorough of all the digestive juices of the body, for it digests proteins, carbohydrates, and fats.

FOOD AND NUTRITION

The human being is for ever wasting and rebuilding the substance of his body. All the cells are continually crying out for oxygen, water, proteins, sugars, fats, and salts. These they obtain from the lymph, the lymph from the blood, and the blood from the lungs and alimentary canal. The assimilation of nutrient substances by the body-cells constitutes the phenomenon of *nutrition*. When, as is the case with the healthy adult, the intake of food exactly balances the export of waste-products the equilibrium of nutrition is established. The amount of food each person requires depends not only on the nature of the food given, but is determined by the age, sex, amount and nature of the work done, &c.

Disregarding the lungs, the only channel by which nutrient material can be introduced into the system is through the alimentary canal. A man takes daily into his mouth a certain quantity of solid and liquid food in the form of meat, bread, butter, water, &c. The substances which are used as food come under the four following heads:

Proteins are composed of carbon, nitrogen, oxygen, hydrogen, phosphorus, and sulphur. They are contained in ordinary meat, bird, fish, egg, milk, and the gluten of flour.

Carbohydrates are composed of carbon, oxygen, and hydrogen only. They are contained in the starches and sugars.

Fats are composed of carbon, oxygen, and hydrogen only.

Salts are composed of metals in association with such elements as chlorine, sulphur, and phosphorus (chlorides, sulphates, phosphates, &c.).

A man weighing 147 lbs. loses in twenty-four hours 3000 grammes of water, 300 grammes of carbon, 20 grammes of nitrogen, and 30 grammes of salts. Taking these results as a basis, it is easy to estimate the amount of food to be consumed. Thus, if fed on bread alone, 4 lbs. per day would be required; if fed with meat alone, 6 lbs. would be necessary. If, on the other hand, 1 lb. of bread and ½ lb. of meat were given, they would suffice to obtain 330 grammes of carbon and 19 grammes of nitrogen, which is approximately equal to the daily waste.

Beginning with the ordinary food constituting the customary meal, received into the mouth it is ground by the teeth and mixed with saliva, which not only serves as a lubricant, so facilitating the act of swallowing, but it also converts some of the insoluble starch into soluble sugar.

Entering the stomach, the food becomes converted into a pulpy mass known as *chyme*, the proteins (as represented by such articles as meat, egg, fish, and bird) being transformed into soluble substances known as *peptones*. On entering the duodenum the chyme becomes intimately mixed with the pancreatic juice which puts all the finishing touches on the process of digestion—converting the proteins into peptones, the starches into sugar, and finely dividing the fat so as to render it available for absorption.

The chyme now becomes *chyle*, which, slowly travelling along the many feet of the small intestine, parts with all its nutrient substances to the blood. From the blood, the proteins, sugar, fats, &c., ooze through the thin walls of the capillaries into the lymph, which delivers them up to the cells which incorporate—or to use the proper technical term—assimilate them.

This assimilation of the food-stuffs by the cells is known as *anabolism*, which is essentially a building up. But, side by side with the building up, there is a wasting process going on, as the cell is yielding up heat and expending energy in other ways. This wasting process is known as *katabolism*. To put the matter as simply as possible: the cell is continually undergoing waste and repair. The former is known as katabolism, the latter as anabolism. The sum of the two is *metabolism*. This is the sum and substance of nutrition.

The Kidneys.—The chief products of metabolism (*i.e.* waste-products) are carbonic acid, urea, and uric acid. The main channels for the elimination of carbonic acid are the lungs; the main channels for the elimination of urea and uric acid are the kidneys.

These organs, two in number, are placed at the back of the abdomen, one on each side of the spine. Like other glands, they are composed of minute tubes lined by epithelium.

The *Urine* is the fluid secreted by the kidneys, and holds in solution urea, uric acid, and sundry other substances of less importance. It is conveyed by two tubes (one for each side), the *ureters*, to the bladder.

The *Bladder* is lodged in the pelvis, and is a muscular bag with a capacity of about 2 pints.

The excretion of urine by the kidneys is constant, and flows, drop by drop, into the bladder. There it accumulates until its quantity is sufficient to evoke the particular sensation necessitating its expulsion through a tube called the *urethra*. This periodic expulsion of the urine is known as the act of *micturition*.

The kidneys, then, are to be regarded as filters, with remarkable powers of discrimination, allowing certain substances to pass through from the blood, but refusing to allow other substances to pass through.

THE SKIN, OR INTEGUMENTARY SYSTEM

The skin is the membrane which covers the whole outer surface of the body. It consists of two parts: (*a*) the *epidermis*, composed of epithelium; and (*b*) the *dermis*, lying beneath the epidermis, and composed of tough fibrous tissue.

The epidermis consists of several superimposed layers, the cells at the surface being in the form of horny scales, while those deeper down are cubical. The cells at the surface are constantly being shed, their place being taken by the upward growth of cells from below.

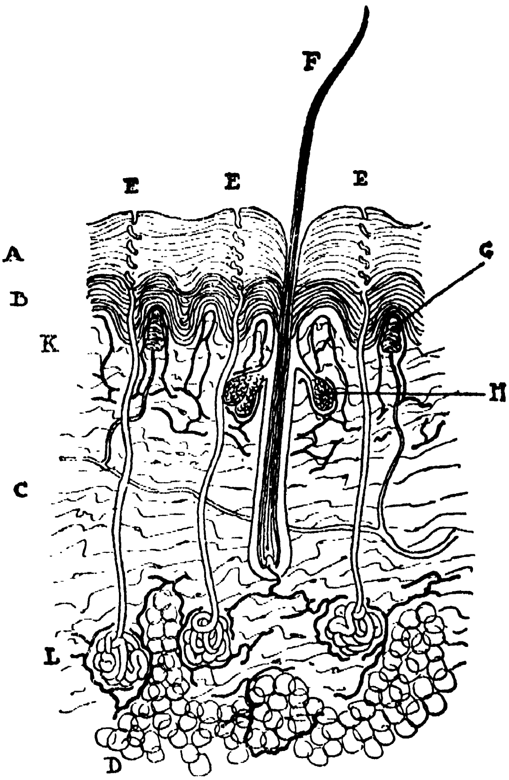
Opening on the free surface of the skin are the ducts of the *sweat-glands*—over two millions in number.

Hairs, which are found nearly everywhere on the skin, are modified epithelial cells. Each shows the following structure:

The Hair-follicle.—This is a kind of tiny bag, buried in the skin, and opening on to the surface by a funnel-shaped mouth. At the bottom of the bag is a heaped-up mass of epithelial cells, somewhat suggestive of the "knock-up" of a wine-bottle. It is by the continuous conversion of these epithelial cells into a horny matter that the hair itself is formed. Opening into the side of each hair-follicle is a *sebaceous gland*. This gland secretes a fatty material which serves as a natural ointment, preventing the hair from becoming dry, as also keeping the skin supple.

Nails are likewise modified epithelial cells. In the case of the hairs, the growth is limited, every hair falling out in due time to be replaced by a new one. In the case of the nails, the process of growth has no limit, the length of the nail being kept down either by "cutting," or by the wearing away of its free end.

The substance of the nail is made up of a large number of densely packed horny scales forming a continuous plate. All these cells are



Section of Skin (greatly magnified).

A, upper skin; *B*, rete malpighii; *C*, under skin; *D*, fat cells; *E*, pore, *i.e.* opening of sweat duct from sweat gland; *F*, hair; *G*, touch corpuscle, connected with nerve; *H*, sebaceous gland; *K*, superficial plexus of blood-vessels; *L*, deep plexus of blood-vessels.

derived from a continuous multiplication of the epidermic cells of the nail-bed (the so-called "quick" of the nail) which, forcing their way up from below, causes the nail to elongate forward.

Perspiration.—Water, in the gaseous state, and so invisible, is constantly given off from the skin. This constitutes the *insensible* perspiration. After violent exercise, or when the body is exposed to a hot and moist atmosphere, drops of "sweat" appear on the surface. This constitutes the *sensible* perspiration.

As a certain amount of carbonic acid (and possibly other waste-products) escapes with the perspiration, the skin is to be regarded as an excrementitious organ.

The Bodily Temperature.—We have seen that

all the cells of the body are constantly undergoing metabolism, taking up oxygen, water, proteins, fats, sugars, and salts, and giving out waste-products. One important product of metabolism is *heat*. In a sense all parts of the body are continually burning, some more rapidly and fiercely than others, and the reason that the temperature remains the same throughout is that the blood, circulating with great rapidity, warms all regions as a house is warmed by a hot-water apparatus.

As the muscles constitute the greatest bulk of the body, they yield the most heat. After the muscles ranks in importance the liver, and then the other organs and tissues, in ratio to their size and metabolic activity. It is computed that about 90 per cent. of the food is used up for the generation of heat, and this being so, it can be understood that more food is required in cold weather, and less in hot weather.

As heat is produced, so it is lost, principally from the skin, and to a less extent by the lungs—expired air being much warmer than inspired air. Heat-production and heat loss exactly balance each other. In this way a constant temperature is maintained, which varies in different species of animals.

Man . .	98·6° F.	Rabbit .	103·1° F.
Monkey .	100·6° F.	Guinea-pig	102·4° F.
Horse . .	100° F.	Hen . .	108° F.
Dog . .	102·2° F.		

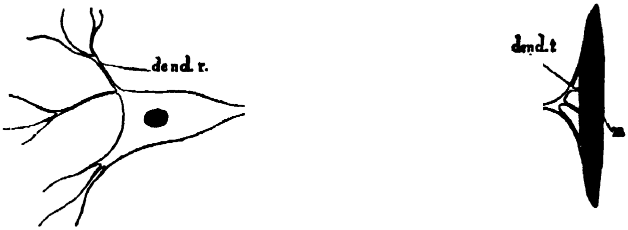
The adjustment of heat-production to heat-loss is controlled by the nervous system. Take, for example, a cold day. The body then is losing more heat, and unless this increased loss is met by increased gain, the body temperature must fall. What happens is this. Cold, impinging on the skin, causes a message to be flashed up by the afferent nerves to "nerve-centres" situated in the brain and spinal cord. The message is transmitted by efferent nerves to the muscles, causing them to produce more heat; so the extra heat-loss is balanced by the extra heat-gain.

THE NERVOUS SYSTEM

The nervous system is composed of the brain, spinal cord, and various nerves. The brain and spinal cord together form the cerebro-spinal axis—lodged in the cavity of the skull and vertebral column.

Passing off from the cerebro-spinal axis are a number of nerves. Those which carry messages to the cerebro-spinal axis are called *sensory* or *afferent;* those which carry messages from the cerebro-spinal axis are called *motor* or *efferent.* For example, an ordinary sensation is conveyed along an afferent nerve; a muscle is moved by an impulse travelling along an efferent nerve.

At the further end of the nerve is the "nerve-ending." In the cerebro-spinal axis it connects with the "nerve-centre." The nerve-endings are engaged in receiving messages which they pass on to the nerve-trunks, just as the telegraph officer receives the various telegraph messages and commits them to the wires. The nerve-trunks afford a line of communication between the nerve-endings and the nerve-centres, and



Diagrammatic Figure of a Neuron or Nerve Cell in connection with a Simple Muscle Cell.

ax, axon; *dend. r*, receptive dendrites; *dend. t*, terminal dendrite; *m*, muscle cells.

may be compared with the telegraph wires, while the nerve-centres receive the messages transmitted along the nerve-trunks, and act according to the nature of the information received, just as the recipient of the telegram may either flash back a message in return or take no further notice of the matter.

As an illustration, take the case of the skin. This tissue is abundantly supplied with nerve-endings, and these latter are placed in communication, by nerve-trunks, with certain centres situated in the spinal cord and brain.

Let us for a moment imagine the brain-centres to be cut off, as in sleep, while those of the spinal cord remain awake. The head telegraphic office is, in fact, closed for the time being, while the branch offices still remain open. Suppose, now, the skin of a man in this condition be irritated as by tickling the sole of the foot. The leg will rapidly be drawn up. This is an example of *reflex action.* What happens in this case is that the nerve-endings receive the impression, flash it up by the afferent nerves to a group of nerve-cells ("nerve-centre") in the spinal cord specialised for the purpose. These nerve-cells then transmit the impression by the efferent nerves to the appropriate muscles, which, contracting, draw the leg away from the source of irritation. The winking of the eyelids at a flash of light or a threatened blow is another example of reflex action.

Sensations are impressions made upon the mind through the medium of one of the sensory nerves. Examples are: the sense of Touch, the sense of Sight, the sense of Hearing, and the sense of Smell. In all these cases, impressions are made upon certain nerve-endings and thence flashed up to the brain.

THE EYE AND THE SENSE OF SIGHT

When we speak of light we think of a certain brightness which pervades all space where light shines, but the fact is that the brightness exists in the brain alone; it is a sensation. Just as the sensations of pain and taste do not pervade space, so this bright light does not; annihilate all mind, and the light—the *sensation* of light—no more exists than does pain or taste. The term light is given to two entirely different things—*viz.* to the peculiar commotion of matter which causes in us the sensation of light, and also to the sensation of light itself; we use, in fact, the same term for the cause of the sensation and for the sensation itself. When a sharp body by contact with the skin causes pain, we do not call this sharp body *pain*, but as the cause of pain; nor do we speak of an apple as taste, but as the cause of taste. When a body is heated so that it throws out light, its particles are driven into the most violent commotion. Each particle vibrates with inconceivable rapidity. Surrounding the luminous body, and pervading all space, is a substance called *ether*. The particles of the luminous body, beating with enormous rapidity against the delicate ether particles which surround it, throw these into rapid vibration. These communicate their motion to adjacent particles, and these again to particles further on, until finally the eye is reached and the sensation of sight evoked. It takes but one second for light to travel 186,000 miles!

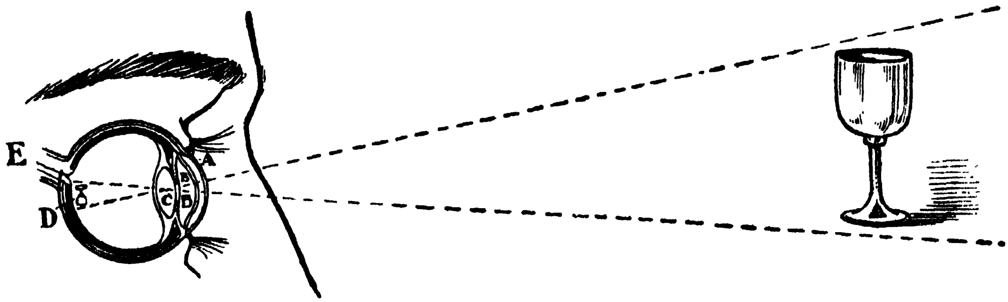
Parts of the Eye.—Look carefully at a friend's eye. In the centre is a black spot. This is the either grey, blue, or brown. The colour of the iris depends upon the presence of pigment, the object of which is to prevent light from penetrating it. The blue eye has a scanty supply of pigment and so is well adapted for the mild sun of the northern countries.

The black eye of the negro, laden with pigment, enables him to endure the fierce glare of the tropical sun. All infants are born with blue eyes and do not assume their permanent colour till the sixth or eighth week. Another function of the iris is to regulate the amount of light entering the eye by varying the size of the pupil. When the light is strong the pupil contracts; in darkness the pupil becomes large.

If you look closely at the eye, you will note that the pupil and iris are covered by a transparent membrane, shaped like a watch-glass. This is the *cornea*, and it is it which gives lustre to the eye.

Outside the cornea is seen the "white of the eye." This is the *sclerotic*, and its use is to form a strong covering to the delicate contents of the ball, and to afford attachment to the six muscles which move it.

The Optic Nerve.—Entering at the back of the eye is the *optic nerve* which spreads out into a delicate membrane covering the whole interior of the sclerotic. This membrane is a nerve-ending—the retina—and is by far the most important part of the eye. In fact, all other parts of the globe are its servants, for the vibrations of ether striking against it cause a message to be flashed up by the optic nerve to the brain, *and there is light.*



A, is the cornea or outer part of the eye: *B, B*, the iris or coloured part, in the centre of which is the pupil, or window of the eye, through which the rays of light pass and are focussed by *C*, the lens of the eye, impressing the image of the glass on the retina *D*, the sense of sight being conducted by the optic nerve *E* to the brain.

pupil. Through it passes all the light of the world outside. The eye is a hollow ball, and when we look through the pupil we are looking into the interior, and if we use an instrument called the ophthalmoscope we can see all its details. Outside the pupil is the coloured part—the *iris*. The "colour" of the eye depends upon the colour of the iris. When we say that a person has blue eyes, or grey eyes, or brown eyes, we mean that the iris in these eyes is

The retina is transparent—*i.e.* it has the property of transmitting rays of light. The sclerotic is bright, and reflects light like a mirror, *i.e.* throws it back. Suppose, then, rays of light fall upon the retina. Unless there be something to intercept them, they will strike upon the bright sclerotic, and be reflected back through the transparent retina on to the other parts of its surface (being a hollow cup). Under these circumstances the retina would be kept in

a constant state of irritation, and the eye would be dazzled by the faintest light. To meet this difficulty nature has interposed a special pigmented membrane termed the *choroid* between the retina and the sclerotic, the function of which is to absorb the rays of light which pierce the retina.

The Lens.—The normal eye is so constructed that the parallel rays coming from a distant object can be focussed on the retina when the eye is in a state of rest. When an object is near to the eye its rays enter divergent, and unless the eye possesses some means of throwing the focus forwards, the image will be formed behind the retina. Now, behind the pupil is an elastic transparent lens—the *crystalline lens*. It is enclosed in a capsule which, under ordinary circumstances, keeps its anterior surface partially flattened. There is a certain internal arrangement of the eye which allows this capsule to be loosened, and when this occurs the anterior surface of the lens bulges and so becomes more convex. Now, the more convex a lens the sooner its rays are brought to a focus. This variation in the convexity of the crystalline lens, to the end that the rays proceeding from the object looked at may be focussed exactly on the retina, is called *accommodation*.

To complete the building up of the eyeball, it only remains to state what fills up the ball in front of the iris and behind the lens. The space between the cornea and iris is occupied by fluid—the *aqueous humour*. Behind the lens lies a transparent jelly-like substance—the *vitreous humour*.

Light, then, has no material existence whatever; it is a sensation resulting from the action of ether-vibrations of different rapidities and wave-lengths upon the nervous apparatus of the eye. It is the mind which receives all these vibrations and translates them into the sense of sight.

THE EAR AND THE SENSE OF HEARING

Sound is conducted, not like light, through an imponderable ether which pervades all space, but through ponderable media such as air and other elastic bodies. The aerial vibrations set up by a sounding body are conducted to the external ear which serves to focus them. They then pass down a passage—the *external auditory canal*—at the bottom of which is a delicate partition, the *membrana tympani*. On the inner side of this partition is an air chamber—the *tympanum*—across which stretches a movable chain of bones (ossicles). On the inner side of the tympanum is another chamber filled with fluid, and separated from the tympanum by a membrane. This second chamber is the *labyrinth*. In the fluid contained within the labyrinth float the nerve-endings of the auditory nerve.

After passing down the external auditory canal, the aerial vibrations strike against the membrana tympani and cause it to vibrate. The vibrations are then transmitted through the chain of ossicles to the membrane on the inner side of the tympanum, which in its turn vibrates. The vibrations of this membrane are communicated to the fluid contained in the labyrinth. The vibrations in this fluid are interpreted by the nerve-endings of the auditory nerve which, flashing them to the brain, evokes the sensation of hearing.

The Sense of Smell.—The nerve-endings of the sense of smell are embedded in the delicate *olfactory mucous membrane* which lines the upper parts of the nasal cavities. Currents of air entering the nose and laden with particles of odorous matter stimulate this mucous membrane, and in this way evoke the sense of smell.

The nerve-endings of the sense of taste lie in the mucous membrane of the tongue and palate. What we call taste, however, is a complex sensation into which smell and touch largely enter. It is a common experience for a "cold in the head" to seriously impair the satisfaction of eating a meal.

In conclusion, it is to be noted that neither sight, sound, taste, or smell have any objective existence. The taste, for example, does not reside in the apple. They are sensations. Specialised nerve-endings receive and interpret a particular impression, and, flashing it up to the brain, evoke the mental concept of either sight, sound, taste, or smell.

REPRODUCTIVE ORGANS

In the *male* these consist of the testes, the epididymis, the vas deferens, and the penis.

The *testes* are the glands, situated in the scrotum, which secrete the seminal fluid. Each testis has attached to it a much coiled tube, the epididymis. Passing from the epididymis is a long tube, the vas deferens, which serves to convey the seminal fluid from the testis through the epididymis to the urethra—the tube which passes from the bladder and through the penis.

The testes attain maturity at puberty. During this period of life the "secondary sexual characters" develop, *i.e.* hair grows on the face and pubes, the voice changes and deepens by about an octave. Also, certain profound psychical changes are noticeable—the egoistic boy becomes the altruistic man.

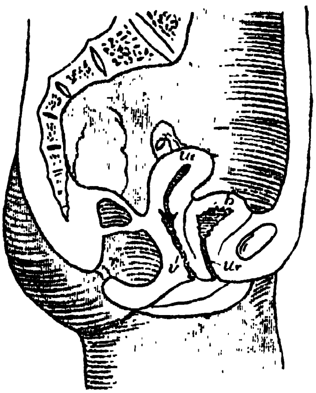
In the *female*, the reproductive organs consist of the ovaries, the Fallopian tubes, the uterus and vagina.

The *ovaries* are two flattened oval-shaped bodies lying in the pelvis (*i.e.* the bony framework situated between the spinal column and the lower extremities). They contain a vast number of special cells known as ova. A

Fallopian tube passes from each ovary to the uterus.

The *uterus* (or womb) is of pyriform shape and lies in the middle of the pelvis. Below it is in communication with a curved canal—the vagina.

The menstrual discharge first commences about the fifteenth year, and recurs about every



The Female Reproductive System.

O left ovary; *Ut*, uterus (womb); *v*, vagina; *b*, bladder; *Ur*, urethra; *r*, rectum.

four weeks up to the age of forty-five to fifty. At the onset of the first menstruation, the breasts enlarge, the pelvis gradually assumes its characteristic feminine shape, and the girl-child develops into the woman.

Reproduction.—This is the process whereby new individuals are generated and the continuation of the species ensured. It consists in the production, and subsequent fusion, of two distinct cells, a germ cell, or *ovum* provided by the female, and a sperm cell, or *spermatozoon* provided by the male. Impregnation consists in the union of these two cells to form a new cell—the *zygote*—from which the future individual is developed. The zygote first divides into two cells, these into 4, 8, 16, 32, 64, and so on until what is now called the *embryo* consists of a vast number of cells arranged in the form of a ball. In course of time three main layers can be distinguished in this ball, the *epiblast*, the *mesoblast*, and the *hypoblast*.

It is from these three layers that all the structures of the body take their origin, the cells becoming differentiated into groups, those of one group being like each other but unlike those of other groups, each group of cells being designed for special work. Thus from the epiblast we have derived the skin with its appendages (hair, nails, &c.); the crystalline lens of the eye and the nervous system; from the mesoblast, the bones and muscles; from the hypoblast, the epithelium lining the entire length of the alimentary canal, the liver, and pancreas.

As nine months go to the shaping an infant ripe for its birth, so many millions of ages have gone to the making of man. He is now the first, but is he the last?

Conclusion.—Faraday was once asked by a beginner called upon to deliver a lecture to a highly select and cultivated audience what he might suppose his hearers to know already. Whereupon the great master replied: "Nothing." The foregoing article is written on the assumption that the reader knows nothing of the matter discussed, and is merely an humble attempt to give the rudiments of Physiology and Anatomy in the plainest possible language, technical terms being very sparingly employed.

COURSE OF READING

The student who wishes to obtain a more thorough knowledge of the subject is strongly advised to attend a course of instruction such as is given in many of the continuation schools throughout the country.

If this is impossible he should read carefully *Physiology for Beginners* by Foster and Shore. Another manual is Moore's *Elementary Physiology and Anatomy*, and this may be taken as supplementary and for revision. The student should work through one of the classical handbooks, either Starling's or Halliburton's *Physiology*.

For books on Comparative Anatomy see Zoology, p. 815.

ERNEST CAMPBELL, M.B.

X. MENTAL SCIENCE

The Meaning of Philosophy.—All branches of knowledge were once, as the literal meaning of the Greek word φιλοσοφιά implies, included in philosophy; it comprehended, only in the sense of containing, all knowledge which in early days had been acquired and was being pursued. But as knowledge grew, and branches of knowledge became defined, philosophy surrendered its occupation with matters of detail to the separate sciences and became comprehensive in a different but wider sense. Its independence of the special branches of knowledge was the independence of a critic surveying the conceptions of those special branches from a point of view which Plato called συνοπτικός, a point of view which, taking in all points of view enabled a conception of the universe as a whole to be arrived at.

But this definition of philosophy, merely emphasizing its over-lordship and criticism of the sciences, does not sufficiently present to us the fundamental aim of philosophical reflection. Its searchings go beyond the desire to adjust differences and to formulate harmony between the various conceptions which the separate sciences present to it; it is first and foremost concerned with the discovery from such conceptions of what really *is*, in contradistinction to what *appears to be*.

This, as we shall see, constitutes the great question of Metaphysics, that science which has been concerned with the nature of Being, over and beyond the physical, as the name metaphysics (μετα-φυσικος, beyond physics) signifies.

History of Philosophy.—Nor can we ignore those considerations which gave the meaning of philosophy a practical tinge. The Greece which gave birth to that conception of philosophy as a comprehensive, independent science, was a Greece in which the primitive, mythological idea of the universe was being slowly shaken, a Greece in which men looked to philosophy for, and philosophy sought to find, if not a new religion, at least some governing rules of conduct to replace the old, religious sanctions. The earliest philosophers confined their inquiries to the physical, and were entirely taken up with the attempt to discover the nature of an elemental world-substance to which all the phenomena of external nature could be referred. Thales and Anaximenes (about the sixth century B.C.), who were the most representative of this school of philosophy, generally known as the Milesian School of natural philosophers, respectively postulated water and air as the abiding, elemental substance, or original ground, from which all things arose and to which they again, after enduring temporal changes, returned.

But these finite explanations of the ceaseless metamorphosis of nature soon gave way to conceptions of an elementary matter beyond experience, and in the Eleatic School which in the fifth century B.C. succeeded the Milesian School, metaphysical ideas began to characterise the conceptions of philosophers. The necessity for going beyond experience had indeed inspired Anaximander, one of the Milesians, who had postulated infinity, both in time and space, as a necessary attribute of the ἀρχή, or first beginning of things. Anaximander, too, was the first philosopher to link philosophical thought to religious idea, by claiming the attribute of divinity for his conception. Moreover, his introduction of the notion that things perish in expiation of injustice, foreshadows the idea which came later in the development of philosophical thought of grounding metaphysical conceptions upon an ethical basis.

So that even in early philosophy can be traced the dim beginnings of the tendencies which may be said roughly to divide the period of Ancient or Greek Philosophy into three stages.

The earliest philosophers of all, starting from Thales, were not much more than students of external nature; and though their studies developed into metaphysical inquiry, that inquiry was not complicated by any doubts as to the existence of a single cosmic matter which should explain the universe.

Questions concerning the validity of knowledge and its psychological aspect were first raised in the Socratic or Sophist period, and, in consequence, metaphysics assumed under Plato and Aristotle (fourth century B.C.) the importance which makes this second period stand out as the great age of Greek philosophy; while in the third, or post-Aristotelian stage, the conception of philosophy as an art of life, wherein should be found guidance for practical conduct, was dominant. Stoicism, Epicureanism,

and finally Neo-Platonism were so many developments of this conception, and successively held sway until the period of Greek philosophy closed with the downfall of Rome.

Mediæval Philosophy.—Throughout the period of mediæval philosophy, from about the ninth to the sixteenth century, the practical conception prevailed, expressing itself in elaborate efforts to find a metaphysical basis for theological doctrine. From such a subservient position to the Church, philosophy emancipated herself in the Renaissance, and we may date the modern period from the time of Descartes (1596–1650) onwards.

Modern Philosophy.—To follow even the barest outline of the successive stages of modern philosophical thought, which is all that could here be given, would require from the reader a knowledge of metaphysical terms which it cannot be assumed that he yet possesses. In the pages devoted to metaphysics, an attempt will be made to acquaint him with some of these terms, and the problems which they imply.

It may, however, be possible to indicate one limitation to metaphysical inquiry which certain prominent phases of modern philosophy have insisted upon, and that limitation may be looked upon as in part a repudiation of the possibility of attaining what the older metaphysicians conceived to be their goal, namely the discovery of the ultimate reality which underlies the facts of immediate experience. The search for a knowledge of that which immediate experience cannot give, which is transcendental, and apart from the world as we know it, has been condemned by some people as fruitless, and philosophy has, for such as pass this condemnation, resolved itself into an inquiry of what we *can* know.

Whichever view we may adopt, the occasion for choice will not present itself, and the ability to choose will not be ours, until some elementary notions of metaphysical inquiry have revealed to us the surprising uncertainties which attend our acceptance of any knowledge whatever, and these elementary notions will be discussed under the head of Metaphysics.

In so far, then, as metaphysics presents to us those uncertainties, it must always form the central matter of philosophy. Logic, inquiring into the principles which determine right reasoning; psychology, which examines consciousness; ethics, or moral philosophy, which investigates conduct from the standpoint implied by our notions of right and wrong, are subsidiary sciences, and only in so far as they bear upon the central question of metaphysics are they properly to be included in philosophy.

Yet logic must be the gate of approach to the study of metaphysics, since it alone can give us the laws which enable our minds to pass correctly from one statement to another.

LOGIC

Introduction.—Logic is the science and also the art of exact reasoning. It teaches us those laws upon which good reasoning depends, and it is therefore indispensable to knowledge.

We can, of course, get knowledge without reasoning; but to reject the reasoning process would oblige us not only to make active trial of the behaviour of every single thing about which we wanted to know, involving a very serious limitation and possibly a full stop to our actions altogether, but to burden our memories with an immense number of separate facts which we should have no power at all of combining.

The first thing we do when we begin to reason is to notice cause and effect—that is to say, we are conscious of something *having* happened to bring about something that *is* happening. That which *is* happening does not, in such a case, fall upon us like a bolt from the blue, or we have some idea, however dim, of that which made it fall. That idea, we tell ourselves, is a reason. And that power of connecting the two things *i.e.* that which *happened* and that which *is* happening—is the beginning of the reasoning process. For instance, from experience of the fact that nettles sting us when we touch them, we reason the undesirability of touching nettles. Now this connection is not stored in our minds uselessly. It enables us to make tolerably certain, or at least to expect, that if the first thing, *i.e.* the cause, happens again, the second thing, *i.e.* the effect, will also again happen. "Expect" was used instead of "come to a conclusion" because the latter expression takes for granted what is being explained, which is the beginning of logical thought. For to come to a conclusion is a reasoning process, and consequently one with which logic has to do, yet phrases implying logical methods are so much a part of our ordinary language that we use them without realising that we are in a sense expressing ourselves technically.

In this fact lies at once the simplicity and the difficulty of the teaching of logic—simplicity, because it ought not to be difficult to explain to people who are already in some measure logicians what are the principles which guide their thinking; difficulty, because it is not so simple as it seems to make people see the necessity of studying principles which they already use without studying them.

But though we are all logicians of some kind, and have been logicians ever since we began to speak, it does not follow that we are all good logicians. Our reasoning may be bad reasoning; we may "jump," as the saying goes, to conclusions which we should never have arrived at had we looked carefully into the nature of the knowledge from which we "jumped." We cannot jump logically, as we often do physically, from unsure to sure ground; if the knowledge from which we start is insecure, our mental jumps will land us on ground that is insecure too. That is why it is important to make certain of the knowledge from which we start to reason. For though logic does not, as an *Art*, occupy itself with the investigation of the grounds, or what are called the *premises*, of our argument, but is concerned with the correctness of what is called the argument, yet incorrect premises are so often a result of illogical thought as well as of careless observation, that, unless we argue merely for mental exercise, it behoves us to examine the facts which our premises state.

Logic, then, in so far as it helps us to correct knowledge of *what* and *why* things are, in so far as it validates our thought, is a *science*; considered as a prescriber of conditions by which we argue correctly, it is an *Art*.

Induction and Deduction.—Our everyday reasoning is sometimes very much at fault. From hasty or careless observation, we are liable to confuse causes and to judge merely by the appearances of things. We take for granted that if things look alike, they are alike; also we are apt to think that if things are alike in one respect, they are alike in all respects. This is what happens when we mistake a draught of poison for a glass of water, or put salt in our tea instead of sugar. The consequences of such mistakes do not always, as we know, give us the opportunity of being more careful in future.

In order to find out the real nature of things, we need not only to make the best use of all our senses, sight, hearing, smell, taste, and touch, but to reason as well. Then, from knowledge of how things behave in a variety of circumstances, we get to a wider knowledge of what is true of certain things in all circumstances and such truths we label laws of nature. When we discover from the behaviour of things such a truth, our process of reasoning is called, in logical phraseology, an *inductive* process; when we discover what will happen in consequence of a law of nature, we *deduce*.

Now *inductive* reasoning, *i.e.* working back-

wards from effects to cause, is a much more complicated and difficult business than working forwards from cause to effects, which is *deductive* reasoning.

The discovery of the motive power of steam, though it was suggested by noticing the lid of a kettle moving when the water inside was boiling, required a great many more experiments, involving careful deductive reasoning, than that provided by that first object lesson. No one can possibly grasp the process of induction until he has had some experience of deduction.

DEDUCTIVE REASONING

Elements of the Reasoning Process.—The laws of logic are concerned with three elements of the reasoning process, *terms*, *propositions*, and *syllogisms*. For instance, a simple argument such as

All swallows are migratory,
This bird is a swallow,
Therefore this bird is migratory,

consists of three statements, or *propositions;* each proposition is made up of *terms* connected by the verb "is," called the *copula;* the whole argument constitutes the *syllogism*.

Terms, we see, are combined into propositions, and the combination or joining together (syllogism, from **συν**, together, and **λογος**, thought) of the first two propositions or *premises* results in the inference of the third proposition or *conclusion*.

"All swallows," "migratory," "this bird" are the *terms* in the above argument; in the first proposition, or *major premise*, "migratory" is said, in logical phraseology, to be *predicated* of "all swallows," which is called the *subject* of the proposition. The second proposition is called the *minor premise*.

The mental operations, or thoughts, which express themselves in language in terms, propositions, and syllogisms are spoken of as Apprehension, Judgment, and Reasoning; and a great many logicians speak of apprehensions and judgments instead of their products in language, terms, and propositions, because they maintain that logic is concerned with the thoughts which the words indicate and not with language. But inasmuch as language is indispensable to the communication of thought, even if it is not essential to thought itself (which point is, however, disputable), and as our reasoning with other people depends upon our ability to reduce that thought to its lingual expression, we may accept Terms, Propositions, and Syllogisms as the subject matter of the three divisions of Logic.

Returning to our simple argument, we see that in it there are in all three terms, "swallow," "migratory," "bird," and that in the whole argument each term occurs twice, the first two propositions having one term, "a swallow," in common, and the third proposition, which is deduced from the other two, being formed by connecting the two remaining terms "bird" and "migratory."

So that given three terms, A, B, and C, and a copula, *is*, it would seem as if the construction of an argument were perfectly simple, as follows:

(1) A is B,
(2) C is A,
therefore (3) C is B.

But we cannot by joining any terms and propositions together in this way be certain of getting a valid argument, for the reason that the first test to which the construction of a proposition, and therefore the choice of terms are subject, is the condition of "making sense," and this condition exacts from terms and propositions certain requirements which it must be our business to investigate before proceeding to the study of the scheme or analysis of the whole sound argument which is called the syllogism.

First of all, then, we will examine terms.

Terms.—There were two terms in the first proposition of the argument above given—*swallow* and *migratory*. *Swallow* is the name of a bird, *migratory* is an attribute, both of them in this case single words, referring to a single thing and a single attribute.

But names and attributes may be composed of a group of words, also they may be the names of a group of things or of a group of attributes.

Thus, though the proposition, "The man who broke the bank at Monte-Carlo is the subject of a popular song" has only two terms, referring respectively to a single individual and a single attribute, there are two articles, one pronoun, one verb, one preposition and three nouns in the first term, and one article, one adjective, two nouns, two articles and one preposition in the second term. And again, the proposition, "The words of the wise are as gold," has only two terms, though the first term, "the words of the wise," makes us think of several things instead of a single thing. But besides singular and plural terms there are also general terms, collective terms, abstract terms, and concrete terms.

A *general* term is the name of a group of things which can also be applied to each member of the group, as, for instance, scrubbing-brush, cat, dog, suffragette, king, sixpence. A *collective* term is also the name of a group, but it differs from a general term in that it cannot be applied to each member of the group separately; such as army service corps, academy, British public.

Many general terms are also *Concrete* terms, *i.e.* they are the names of things which have material existence, such as "sugar," "motor-car," "stars," "houses." ***Abstract*** terms, on the other hand, are the names of things which

have no actual existence, but which are qualities of things, *e.g.* "colour," "height," "virtue," "greed."

Now when a term is attributive, as the term "migratory" is in the example given, it may be attributive in a positive or in a negative sense. That is to say, it may point to the existence or non-existence of a certain quality in a thing. *Negative* terms are such terms as "unpopular," "untidy," "worthless," "inconvenient," and terms connoting qualities of which the opposites are known may sometimes in respect to their opposites be considered negative. "Ugly," "rough," "opaque," "false," are examples of such negative terms.

But opposite terms are not necessarily positive and negative. We ought to examine their meaning carefully before assuming that one of a pair of opposites conveys the entire absence of that quality which the other indicates. A *dark* day, for instance, does not mean a day that is wholly devoid of light, also the fact that there are several degrees of heat and cold should qualify our assertion that a cold thing is necessarily the negative of a hot thing.

Examination of the meaning of all concrete terms also brings us to see that such terms are just as much the names of the qualities which the things described by the terms possess, as they are the names of the actual things themselves. For instance, though the term *house* is the name of a building with walls and a roof, when we use the term we mean something more than that—we mean the qualities of shelter, accommodation, which that building possesses. Concrete terms, then, while they are *applied* to things, at the same time *imply* qualities of things. In logic, the extent of their application is called *extension;* the extent of their implication is called *intension.* For example, if we compare the term "*country*" with the term "*English country,*" we shall see that by a reduction of extension we have gained in intension, since the term *English country,* though it rules out of consideration all foreign countries, brings to mind many more definite qualities than were brought by the general term "*country.*" Again, substituting "*Kentish country*" for "*English country,*" we reduce the extension still further, but, for those of us who live in Kent, increase the intension.

The use of concrete terms as a rule involves us in no difficulties. Both we and the person or persons to whom we are speaking run comparatively slight risk of misunderstanding each other's meaning. It is only when we get to terms whose meanings are vague or ambiguous that mistakes arise, and if we want to reason correctly we should be very particular to get clear in our minds exactly what the term we are using means to us and make certain that the person with whom we are speaking or arguing means the same thing.

Terms and Classification.—When we have attained to clear ideas of what we mean when we use terms, we shall be within reach of that most important of logical instruments, namely the power of classifying. Our recognition of a term being what is called a general term implies a certain knowledge of what classification is—*i.e.* we recognise that a general term is the name of a group or class of things, but we have not always a conscious grasp of how and why general terms come into being.

The first motive that leads us to classify is noticing likenesses between things, so that when we think of them we think of them together. The point in which they are alike decides our classification. So we classify individuals according to sex, age, ability; races of men according to colour, climate, &c.; colours according to shades, climates according to temperature and so on.

Some of these classifications are very rough, and do not point to any intimate knowledge of the nature of the things classified, but they are useful in so far as they record degrees, however superficial of resemblance. For scientific purposes we need more exact classification, which shall comprehend, if not all, at least the main, properties of the things classified. Such classifications are those given us by botanists, naturalists, ethnologists, chemists, who can, by referring to the class to which a plant, or an animal, or a bone, or a chemical substance, belongs, tell us easily what are its essential characteristics or properties. The more we acquaint ourselves with the methods of scientific classification, the more we realise that outward likenesses are very insufficient clues. Size especially is a poor indication of class, as we know if we have any acquaintance with the classifications of natural history; the habits of animals, on the other hand, are much more trustworthy guides to their real nature.

A class or group, in so far as it tends to extension, requires subdivision from the point of view of its intension, and in dividing the big class or genus of things into the smaller classes or species, we should take care that our small classes do not overlap one another. For instance, if we divide a library into the branches of History, Literature, Mathematics, Science, Theology, Philosophy, we may find we have counted some of the books twice over. For there are some books of which we cannot assert that they belong to one class more than to another. The Bible, for instance, is it literature, history, or theology? The novels of Alexandre Dumas, are they history or fiction? And not only with books, is it difficult to prevent the overlapping of species.

Propositions.—Now that we have come to some idea of terms, we pass to propositions which connect terms. In the proposition "A swallow is migratory" we state something about a

swallow. That about which we state something is called the *subject* of the proposition; that which we state of the subject is called the *predicate* of the proposition. We may make *negative* as well as *affirmative* propositions, in which case our predicate tells us something which is *not* an attribute of the subject as in the proposition "Pheasants are not migratory." There are also *hypothetical* propositions which predicate of the subject under conditions as: "If iron is heated, it is malleable," and *disjunctive* propositions predicating alternative things of the subject, as for instance: "Hair is yellow, brown, or black." It is very important to notice whether a proposition be what is called universal or particular. A *universal* proposition is such a one as "All rivers flow downwards," in which we predicate that flowing downwards is a property of all rivers. A *particular* proposition is one which predicates concerning only a portion of the subject such as: "Some men are savages."

When we predicate affirmatively concerning the whole of the subject, taking in every member of the group of things which the term covers, the subject is said to be *distributed*. We could not distribute our predicate in the above example without undertaking to state that all things which flow downwards are rivers, which would be an absurd statement. A particular affirmative proposition, on the other hand, obviously does not distribute its subject.

In the case of a universal negative proposition, both subject and predicate are distributed as in the example "No coal is edible." We are here asserting not only that edibility does not pertain to any coal, but that among all edible things coal would not be found. A particular negative proposition distributes its predicate but not its subject. "Some men are not gentlemen," by which we mean that in the group of "not gentlemen" some men (obviously an undistributed subject) will be found.

Converses.—Now before going on to the syllogism or to the argument as a whole, we have to learn something about converses—that is to say, we must say what happens when we turn a proposition about, making the subject the predicate and the predicate the subject.

The converse of a particular affirmative proposition is not always true. If we convert the proposition "Some insects are glowworms" into "Some glowworms are insects," we are not saying the same thing, for we are implying that there are glowworms which are not insects, which is untrue. But if we convert another particular affirmative proposition, for example, "Some lions are tame creatures" into "Some tame creatures are lions," we are merely saying the same thing as before. This is called a case of simple conversion.

A universal affirmative proposition cannot be converted simply. If we interchange subject and predicate in the proposition "All swallows are migratory birds" we get "All migratory birds are swallows," which we know is untrue. This is because the predicate in a universal affirmative proposition is not, like the subject, distributed, and therefore the conversion, which in this case is called a limited one, is "Some migratory birds are swallows."

A universal negative proposition, having its subject and predicate alike distributed, can be simply converted. It can also be changed into a universal affirmative, and vice versa. "No rivers do not flow downwards" is exactly the same as saying "All rivers flow downwards."

The Syllogism.—We have already seen that a simple argument consists of three propositions, of which the third is deduced from the first two propositions, which are called the premises. The third proposition is called the conclusion. We have seen, too, that there are three terms in the whole argument, and that the conclusion contains two of these terms—the two which the premises do not share in common. The term which the premises share in common—*i.e.* *swallow* in the example given on p. 836, is called the middle term. It is important to remember that the middle term never occurs in the conclusion.

The other two terms are called the major and the minor term respectively. The major term is the predicate of the conclusion. The minor term is the subject of the conclusion.

The reason for so naming these terms is understood when we consider the three terms in relation to one another. The three terms denote three classes of things, or rather in this case, two classes, "swallows" and "migratory birds" and one particular thing, *i.e.* "this bird." Of the two classes, "migratory birds" is larger than and includes "swllows," while "swallows" includes "this bird." Hence, if we drew circles to contain respectively "migratory birds," "swallows," and "this bird," the circle representing "migratory birds" would contain the circle representing "swallows" which in its turn would contain the circle representing "this bird." So that we see that the major term is that which includes the middle and the middle that which is included in the major, and, in its turn, includes the minor term. It does not matter which proposition we write first so long as we remember that the major proposition is the one containing the major term.

Rules of the Syllogism.—Now for an argument to be a syllogism—that is to say, that for the putting together of two propositions or premises and drawing from them a logical conclusion—there are certain rules to be observed in addition to the rule that *each argument must contain only*

three terms and *only three propositions.* The first of those rules concerns the nature of *the middle term.* That *must always be distributed, i.e.* taken universally, *at least once during the premises.* For instance, if we say:

> Some weeds are poisonous weeds,
> Some weeds are medicinal,

we cannot conclude that poisonous weeds are medicinal because the "some weeds" which are poisonous are not necessarily the same as the "some weeds" which are medicinal. If, however, we say:

> Some weeds are poisonous weeds,
> All weeds are objectionable,

we are perfectly justified in concluding that some of the objectionable weeds are poisonous because "some weeds" must be part of "all weeds," and consequently the major and minor terms can be compared with one another.

Also, *unless a term has been distributed in the premises, it cannot be distributed in the conclusion*—that is to say, we cannot infer anything about the whole of a thing or class of things if our premises tell us only about a part of it. If we know that philosophers are not good men of business, and we also know that some men are philosophers, we cannot infer that no men are good men of business, because we should then be concluding something about other men of whom our premises tell us nothing. We can only infer that some men are not good men of business. The second rule of the syllogism is therefore: If a term be distributed in the conclusion, it must first of all have been distributed in the premises.

We have so far considered only positive conclusions. But *if one premise be negative then the conclusion is negative,* and *we cannot get a negative conclusion unless one premise is negative. From two negative premises no conclusion can be drawn.* This is the third rule of the syllogism. Also *two particular propositions, whether affirmative or negative, give no conclusion.* For here we have what is called the fallacy of the undistributed middle. Take for instance,

> Some factory inspectors are women,
> Some women are militant suffragettes,
> Therefore some factory inspectors are militant suffragettes.

The middle term, which is 'women,' is the predicate of the first proposition which being an affirmative one does not distribute its predicate. Also, as the subject of the second proposition, a particular affirmative, it is again undistributed. Consequently one of the rules of the syllogism is broken. This fallacy of the undistributed middle is one of the main sources of error in our everyday reasoning. Again, *if we try to deduce a general conclusion from two premises one of which is particular, our reasoning will be fallacious.* We cannot conclude from

> Some women are not fit to have votes,
> Well-educated individuals are fit to have votes,

that no women are well-educated because in so concluding we are ignoring the fact that our first premise tells us only something about some women. Such a conclusion breaks another rule of the syllogism.

There are, then, six main rules of the Syllogism:

(1) Every syllogism has three, and no more than three, terms.

(2) Every syllogism has three, and only three, propositions.

(3) The middle term must be distributed once at least in the premises.

(4) No term must be distributed in the conclusion which is not distributed in one of the premises.

(5) Nothing can be inferred from negative premises.

(6) If one premise is negative, the conclusion must be negative.

There are two more rules which are corollaries of these; bringing the number of rules of the syllogism up to eight.

(7) No conclusion can be drawn from two particular premises.

(8) If one premise is particular, the conclusion must be particular.

We see that the propositions composing the syllogism are of four kinds, affirmative or negative, universal or particular.

It has been found that the number of ways in which these four kinds of propositions can be combined to construct a valid syllogism are nineteen, which nineteen ways are called the *nineteen moods* of the syllogism. These moods were arrived at by considering every possible variety of combination of three sets of four propositions, sixty-four in all, and subjecting each combination to the test of the rules of the syllogism above given. There emerge from this trial eleven valid moods, but these eleven have to undergo further test in what are known as the four figures of the syllogism, or ways in which the terms in the propositions may be arranged, and out of the forty-four possible cases, nineteen only satisfy the tests of validity and usefulness.

Fallacies.—In addition to the fallacies resulting from disregard of the light rules of the syllogism there are other fallacies, the classification of which has remained practically the same ever since Aristotle planned it in his treatise on argumentative tricks, over 2000 years ago. These fallacies are divided into classes—the class of verbal or logical fallacies (*in dictione*) and the class of non-verbal or material fallacies which arise outside the verbal expression, *extra dictione.*

The first class contains the purely logical fallacies—those which clearly break the rules of the syllogism, and which need not again be considered, and six other varieties:

(1) The fallacy of *Ambiguity* of word, when a word is not used in the same sense in both premises.

(2) The fallacy of *Amphiobology*, or *ambiguity of structure*, when a sentence admits of a double construction, such as the quotation from "Henry VI" given by Whately, "The duke yet lives that Henry shall depose."

(3) The fallacy of *Composition*, or *illicit process*, such as is involved in the argument: "Victoria was essentially a good woman; she was violently opposed to the enfranchisement of women, therefore opposition to the enfranchisement of women is good."

(4) The fallacy of *Division*, or *illicit disjunction*, another form of illicit process, such as "Charles I was a good husband and father, therefore he was a good king."

(5) The fallacy of *Accent*. "He said, saddle me the ass. And they saddled *him*."

(6) The fallacy of the *Figure of Speech*. Aristotle's illustration of this fallacy was: "Whatever a man walks he tramples on; a man walks all day, therefore he tramples on the day."

Of the material fallacies, the fallacies *extra dictionem*, Aristotle gives seven. The most important of these are:

(1) The *Petitio Principii*, or *begging the question*, or arguing in a circle, when the conclusion it is desired to prove is taken as one of the premises. For instance, "England has to defend herself from Germany, Germany has to defend herself from England, therefore war is necessary." The argument, "The moon is either made or not made of green cheese, it is not made of green cheese, therefore it is made of green cheese," is another instance.

(2) The *Ignoratio elenchi*, or *irrelevant argument*, or arguing beside the point, manifesting itself sometimes in an *argumentum ad hominem* or an *argumentum ad populum*. It has often been spoken of as the politician's refuge.

The other fallacies are less important; they are the fallacy of Many Questions, famous in ancient dialectics, in which many questions are introduced in the guise of one, so that the answerer is committed by the answer "Yes" or "No" to the implication of the question, such as "Have you left off beating your wife?"; the fallacy of Non-Sequitur; the fallacy of *Post hoc ergo propter hoc*; the fallacy of Accident and its converse.

There is unfortunately no space here to consider the questions of *hypothetical* and *disjunctive* syllogisms. The latter are more complicated than the former, which do not really offer any greater difficulties than simple syllogisms. They can generally be stated in such a way as to avoid the hypothesis, and can then be treated as simple syllogisms.

Rule of Inference.—Many arguments, however, do not obey the rules of the syllogisms, but the Rule of Inference affords one valuable test for dealing with some. Roughly the rule is that from a proposition stating a relation between two terms we can always infer the same relation between two other terms which refer respectively to the same things as those to which the first two terms refer. If, for instance, parallel lines never meet, the opposite sides of a square, which we know are parallel, never meet. This rule leads to the principle of the substitution of similars for similars, which is the process by which a great part of knowledge has been reached. It is a principle which has guided all great inductive reasoning.

INDUCTIVE REASONING

The difference between deductive and inductive reasoning has been already pointed out as a difference in direction—*i.e.* by deduction we work forwards from premises to conclusion, by induction, we work backwards from conclusion to premises. All around us are natural phenomena, and it has been the business of scientists for many hundred years to observe and to classify phenomena with a view to the discovery of the various laws of nature which have caused them.

Careful observation of facts presented to our senses is therefore an essential preliminary to inductive reasoning. The scientist, however, while he collects facts, collects them imaginatively—that is to say, his reasoning about them as he collects shapes itself into imagined laws or hypotheses. He next proceeds to experiment with one of these hypotheses to see whether deductions from all the facts he has collected agree with the hypothesis, and he does not put forward his hypothesis as a correct one until there is no shadow of disagreement between it and all his deductions. When agreement is complete he has reached the last stage of inductive reasoning, and is said to have established his hypothesis.

These steps, starting from observation and proceeding through the framing of an hypothesis and deductive processes to verification, are the steps by which all discoverers of natural laws have marched to their great discoveries. There is no royal road to scientific truth. And the greater the scientist the less impatient is he to pass from one step to the next and before he gives his discovery to the world he retraces his steps many times. The history of Darwin's investigations and reasoning processes before he founded that great theory, The Origin of Species, is an object lesson on this point. Great investigator and great thinker as he was, he did not allow himself to speculate the question

until, as he himself tells us, he had spent five years in "patiently accumulating and reflecting on all sorts of facts which could possibly have any bearing on it." Nineteen years after he had first drawn up some short notes on the subject he was induced by his friends to publish what he modestly referred to as an abstract of his conclusions, speaking of the mass of evidence contained in the abstract as "a few facts in illustration" and "necessarily imperfect."

Kinds of Induction.—Induction is of two kinds, Perfect and Imperfect.

For *Perfect Induction*, the premises have to include every possible case to which the conclusion refers so that the conclusion is an absolutely certain one. When the premises do not include every possible case, the induction is *imperfect*.

Since Darwin was obviously unable to observe and examine all possible facts that could have bearing on the case he was studying, his induction was, as he himself said, "necessarily imperfect."

Had he even been able to examine all known facts and to enumerate the same in his premises, his induction would still have been imperfect, since knowledge is not co-extensive with existence, but in such a case, by using the expression "known facts" in his premises, his argument could have been presented in the form of a perfect induction, because his premises would have made no assertion regarding facts outside known ones.

But it is rarely possible to observe, still less to enumerate, all known facts, and in consequence Induction is usually imperfect. Moreover, the certainty of conclusion in the field of physical science is further qualified by an assumption of the principle of reasoning by analogy.

Analogy.—When, for instance, a scientist is examining a material substance such as a piece of chalk, he is not absolutely certain that his analysis of its ingredients is an analysis that will hold good of all other pieces of chalk. It could be only by experience of analysis of all the chalk in existence that he could make an absolutely positive statement regarding chalk. The truth of his analysis therefore would depend upon the assumption that there was an exact resemblance between the piece of chalk he is examining and the rest of the chalk in existence. He assumes the formula given by Mill as the basis of argument by analogy that if two things resemble one another in one or more respects, what is true of the one is true of the other.

By analogy, much of our everyday reasoning is done, and occasionally, if not profound, it leads to very unfortunate mistakes. If our analogy never concerns itself with anything beyond superficial resemblance, it is rarely trustworthy, or if it is trustworthy we are fortunate. Very careful observation is needed to accompany reasoning by analogy if that must be our only guide. Analogy, as someone has said, is a good servant but a bad master.

Now, though for ordinary purposes everyday life supplies us with more material than we can handle for scientific purposes, observation has to be supplemented by experiment, when possible. Very many natural phenomena are, of course, beyond the reach of experiment altogether, and a certain number, such as total eclipses of the sun, earthquakes, occur, comparatively speaking, so rarely that our knowledge of them is necessarily incomplete. But where experimentation is possible, as in the case of chemical substances, for instance, we can not only get intimate knowledge of the action of a certain thing under the particular circumstances in which we have observed it, but of its action under other circumstances which we are able to control. Moreover, by this ability to vary the circumstances, we can discover what is the particular consequence of each separate circumstance, and actually in what that separate circumstance consists.

Antecedent is the name by which we signify each one of the circumstances preceding the event we are observing. To that which follows after the event we give the name *Consequent.* The event itself is called the *Phenomenon.*

Methods of Induction.—From experiments we discover wherein, among the antecedents of a phenomenon, lies its cause. The cause of a phenomenon is that antecedent or antecedents which are always found when the phenomenon happens. Science tries to discover the exact nature of antecedents and the exact order of their importance in producing the phenomenon.

It does this, when it is debarred from experiment, by considering every possible circumstance that was present at every observed appearance on the phenomenon it is studying, and tries to see wherein those various circumstances have points in common. In so doing it is proceeding on the lines of the *first Method of Induction*, namely the method of *Agreement*, expressed by Mill as follows:

"If two or more instances of the phenomenon under investigation have only one circumstance in common, the circumstance in which alone all the instances agree is the cause of the given phenomenon." But in the event of two different causes being able to produce the same phenomenon, another method has to be applied and this is called the method of *Difference.*

"If an instance in which the phenomenon under investigation occurs, and an instance in which it does not occur, have every circumstance in common save one, that one occurring only in the former, the circumstance in which alone the two instances differ, is the effect, or the cause, or an indispensable part of the cause, of the phenomenon." This method is that upon which experiments are conducted, when by varying

one circumstance or set of circumstances at a time, the other circumstances being kept constant, the consequences of each circumstance or set of circumstances can be compared. The investigations into the cause of dew, referred to by Herschel in his *Discourse on the Study of Natural Philosophy*, illustrate this method; a portion of the ground screened from the cloudless sky, but in all other respects subject to exactly the same conditions of temperature as the surrounding unscreened ground, was found to be free from the dew which was elsewhere universal, and enabled the conclusion to be drawn that exposure to the open sky was an indispensable antecedent to the formation of dew.

These two methods, the Method of Agreement and the Method of Difference, have sometimes to be applied jointly in cases when it is not possible to isolate one particular circumstance from the others, though when that circumstance is always present there appears to be a corresponding constant in the result. In such a case, if, by introducing a completely different set of circumstances, the former result no longer happens, there is strong ground for assuming that the particular circumstance is the true antecedent of the phenomenon in question.

Mill defines the Joint Method of Agreement and Difference as follows:

"If two or more instances in which the phenomenon occurs have only one circumstance in common, while two or more instances in which it does not occur have nothing in common save the absence of that circumstance: the circumstance in which alone the two sets of instances (always or invariably) differ, is the effect, or the cause, or an indispensable part of the cause of the phenomenon."

Generalisation is the reasoning process by which we draw, from the facts which observation or experiment in particular cases gives us, general truths or laws concerning the whole class of things to which the particular things belong. Life is too short and the world too large for us to make absolutely certain that what is true of several things of a class is true of every other thing in that class. All we can do is to verify our hypothesis in as many cases as possible, and to found our generalisation upon that. We conclude, and our conclusion is usually corroborated by practical results, that things which are alike in several properties are probably alike in other properties. We cannot be positive about it, but the probability seems to be much greater than the improbability. There are three kinds of *fallacies into which hasty generalisation and faulty analogy* may lead us. These are:

(1) Arguing from the general to the particular,
(2) Arguing from the particular to the general,
(3) Arguing from the particular to the particular.

Though we derive our knowledge of the general from knowledge of particulars, we cannot assume, especially when our generalisation is very extensive, that it holds good in peculiar cases. For instance, though it is true of men in general that they need solid food, there are times in illness when to give solid food to a man would endanger his life. Though, as Mrs. Squeers probably thought, when she daily administered brimstone and treacle to the boys at Dotheboys Hall, all young people are the better for regular medicinal treatment, she was arguing from the general to the particular in a very brutal and thoughtless manner. Again, though the fourth commandment to keep holy the Sabbath day, and in it to do no manner of work, was doubtless in general a wise one, that there were instances when to obey it literally was inhuman was pointed out by Christ Himself. Yet in such a case it is realised that the descent from the general to the particular rested upon the conventional interpretation of the law rather than upon the law itself, and the illustration is perhaps a deceptive one.

So that in applying a general law we have to consider whether the case to which we are applying it is a moral one, that is one from the particular knowledge of which the general law could have been framed. Mrs. Squeers' methods might also have been quoted as an example of the second fallacy, that of proceeding to the general from the particular. The fact that brimstone and treacle is good for some boys every morning is an insufficient reason for assuming that it is good for all boys. However, Mrs. Squeers did not probably reason about it at all, or if she did, the object of her reasoning was to save herself trouble rather than to confer benefit upon the boys. The fallacy of arguing from the particular to the particular partakes more of false analogy than of hasty generalisation. It is false analogy when we reason that because Germany flourishes under a protective tariff Great Britain would also flourish under a protective tariff. Whether we consider that a policy of protection would be good for Great Britain or not, we at least know enough of the different economic conditions in the two countries to realise that if Great Britain did flourish under a protective tariff it would not be *because* Germany flourishes under the same policy.

The only preventive against falling into any of these fallacies is knowledge of the matters about which we are talking.

METAPHYSICS

Metaphysics comprehends the study of the ultimate grounds or first principles of things. That there is some changeless, eternal reality behind the ever changing experiences of this mortal life was the idea which furnished the main stimulus to the reflections of the early philosophers.

And we, to whom the world seems so indubitably real, who have never been stirred to doubt the reality of any of our experiences, may wonder why the necessity arose for such profound searchings. True, we often remark glibly in particular instances, generally connected with personal disappointment, that things are not what they seem, but we very rarely realise that in making such a remark we are in a few words setting forth one of the biggest problems of philosophy. Yet it needs but a very little consideration—consideration involving no abstruse thought—to convince us of the difficulty not only of declaring positively that such and such a thing exists, but of declaring positively that there is any such thing as reality at all.

The Problem of Reality.—To a suggestion that it is very difficult to declare positively that such and such a thing exists one may instinctively retort by an appeal to the senses. It can be seen.

But what of the blind ?

To meet this objection an appeal is made, perhaps, to other senses. Even the blind have the sense of touch, and can therefore reasonably infer the existence of a thing although they cannot see it.

When the objection is pressed further—What is really there, that we can see and the blind can touch ?—it may be grasped that a thing looks different from different points of view. A chair, for instance, may be drawn in this way or in that way. The final objection now emerges—How can the real shape, size, &c., of a thing be known which looks different from different points of view ?

And, however hard we try, we shall not be able to say what the real shape of the chair is, any more than we can say what its real colour is, for the colour that the chair seems to be is just as changeable as the shape ; in some lights it will appear brown with flecks of light where the sunlight strikes it, in other lights it will seem of a dull hue. Looked at from a distance, with the light behind it, it will seem to be black, while we can make it seem what colour we like by looking at it through coloured gla ...

And the more we investigate what we have hitherto considered the real, inalienable features of the chair, the more we shall see that those features are no more than characteristics of its various appearances. Touch, too, gives us no more decisive evidence. The sensations of hardness which we get as we sit on the chair increase as we go on sitting, while, owing to some parts of our bodies being more sensitive than other parts, we cannot say really how hard the chair is. It is the same with the evidence of all our senses ; it is never more than an indication of what the something we are considering seems to be at the moment we are considering it. And yet we believe that the something *is* there, that in spite of our inability to get beyond appearance, this appearance is caused by the existence of a substantial thing, a reality. Though we admit that our knowledge about it can only be in the nature of an inference from what our senses tells us immediately, we still believe that that inferred knowledge is the knowledge of a real, objective thing.

Suppose, for a moment, we admit the contrary hypothesis, that there is no real objective thing, that what we think to be real is merely an illusion of our senses, that only so long as we are looking at it does that thing exist. In dreams we see things which when we wake up we discover to have had no objective existence; in waking life, too, we have sometimes perhaps been confounded by mirages : let us suppose that all our experiences are like dream experiences, that outside things are mirages.

Certain difficulties, however, immediately occur as soon as we deny the independent, material existence of other things than ourselves.

The Difficulty involved in denying Reality.—How can we, for instance, account for the behaviour of people, animals, trees, flowers, and all those things that we include within the term animate life, if we maintain that such things have, so to speak, lapses of non-existence when we are not looking at them ?

How can we explain how a bud which was on a rose tree as we looked at it in the garden yesterday is in full bloom as we look at it to-day ? How can we explain growth, if when we are not there to see it, the bud ceases to exist ? How can we explain any of the changes in the occurrences of daily life, if such changes are

are not the manifestations of continuous action whether we are there to see them or not? Moreover, how can we explain why this denial of independent, material existence should be so inacceptable to common sense?

It is not asserted that we cannot explain it except by the common-sense hypothesis that outside things do exist independently, but it is claimed that, in the face of these and other difficulties, there seems no reason why we should believe that the contrary hypothesis is true. Also the common-sense hypothesis proceeds from an instinctive belief, and unless an instinctive belief proves itself entirely at variance with other instinctive beliefs we are in no position to overthrow it. Each instinctive belief has to run the gauntlet of all other instinctive beliefs, and its survival from such a summary process is in itself a strong argument of its reasonableness. Having reassured ourselves on this point, we come next to the consideration of the nature of that which we instinctively believe does exist outside ourselves.

The Nature of Reality.—Immediate knowledge of the nature of a thing is, we have seen, denied to us; what the real thing is we cannot tell any more than we can tell what is its real shape, real colour, real taste, &c. "Any more than," may, however, suggest a way out of the difficulty. For while it is true that the shape, or colour, we see is not the thing's real shape or real colour, why cannot we suppose that the real shape or colour is anyway something like the apparent shape or colour? The apparent shape, or colour, does, we admit, vary according to the position or place from which we see it, but we can explain these variations by the laws of perspective or reflection, and the real shape or colour may be something in the nature of a medium shape or colour. After all, at least with colour, the differences between the various appearances do not strike us generally as surprising differences; it is often merely a question of shade.

Correspondence.—This argument is a very plausible one and difficult to dismiss, and though we have to dismiss it we need not dismiss the idea which it may contain of a probable *correspondence*, though not *likeness*, between real objects and their appearances. In what that correspondence consists we must discuss later; for the present we have to reject the notion of the probability of there being any *likeness* between appearance and reality.

For, and it cannot too often be repeated, the shape, the colour, the sound, the taste, the smell of a thing are all determined by conditions which have no intrinsic connection with the real object whatever. Not only do our sensations depend upon the state our senses are in, but they also depend upon the condition of that which intervenes between ourselves and the object. Fog, water, the state of the atmosphere, are determinants of colour, shape, and sound, while so are our own physical conditions. Something is there, outside ourselves, to cause these sensations, but there is no tittle of evidence to prove that this something bears likeness to things as we perceive them.

Correspondence is a different matter. As reasonably as we infer from our sensations that external realities do exist, may we infer certain correspondences between the real and the apparent things. But such correspondences are only correspondences in spatial and to a certain extent in temporal relationships.

Assuming that realities exist, we may assume that they exist and hold the same relationship as far as position goes in a real space as the apparent things hold to one another in space as we know it. We have, of course, to distinguish between space as we know it and the real space in which we assume the real objects are placed for the same reasons as led us to distinguish between other appearances and realities.

And in so far as time marks the order in which things happen, we may assume that real events take place in real time in the same order as that in which they apparently take place. We should note particularly that it is only order and not duration of which we are speaking, for our sense of duration is no better guide to real duration than are our other feelings to reality. The hymnal line, "A thousand ages in Thy sight are but an evening gone," however unduly positive upon the matter it may seem, at least shows a proper conception of the subjective nature of the feeling of duration, and we need only compare our personal experiences of half an hour spent pleasantly and unpleasantly to realise this conception more vividly.

The presumption of correspondence may reasonably be pushed a little further. In so far as things appear to be similar or to be dissimilar, a corresponding similarity or dissimilarity may reasonably be believed of their realities, though what the actual nature of that in the real things which gives the appearance of similarity or dissimilarity is we cannot discover immediately. Science may be able to give us her latest theory of the ultimate ground of the phenomena of external nature, but even scientific suppositions force our minds into that unfamiliar *real* space of which we have no immediate knowledge. It seems paradoxical that with reality we can never be familiar, but this apparent paradox is one of the first truths that metaphysics teaches us.

It looks then as if we might reasonably despair of discovering the nature of that which we believe does exist outside ourselves. We are confident that something is there, and yet we don't know what that something is, nor, so far as our senses are capable of telling us, does it seem that we are ever likely to know.

This is the riddle of metaphysics—to explain the nature of that which exists outside ourselves, to discover what that is of which we have only relative knowledge, that is knowledge of its relation to our senses. Our conceptions have hitherto been what are called dualistic; we have thought of the world as consisting of Mind and Matter, Mind which thinks, and Matter which is independent and inanimate. What is the real relation between the two ?

In proceeding to discuss the very different answers which philosophers have given to this question, we shall do well to begin as Descartes (1596–1650) began, with complete open-mindedness and an unwillingness to believe in the existence of anything which could be reasonably doubted.

Descartes' scepticism did not, however, include doubt of his own existence. He found that he could not doubt his own existence because if he did not exist he could not doubt; the fact that he did doubt was proof of the existence of something which could doubt. "I think," said Descartes—"therefore I am." ("Cogito, ergo sum.") From such an indisputable position Descartes proceeded to test the validity of ideas and to develop his theory of innate ideas, those whose intuitive clearness and distinctness were evidence of their truth. From such a standpoint, the truth of "Cogito, ergo sum" was based, not so much upon experience as upon the rational ground of intuitive certainty, and innate ideas, according to Descartes, were those which presented themselves to the mind with as much clearness as the fundamental intuition of self-consciousness.

The idea of *Perfection* which was the first of his innate ideas must, he thought, imply the existence of a perfect God outside himself, since a mind aware of its own imperfections could not of itself conceive perfection. In such a way, certain other innate ideas, among them the ideas of substance and a unity informing all things, carried him into the unknown, or rather, certain *a priori* conceptions revealed to him that which was unknown by experience.

But the scepticism which Descartes had inculcated opposed itself, in other philosophers, to his conclusions. **Locke** (1632–1704) reasserted the impossibility of knowing anything beyond experience, and **Berkeley** (1685–1753) from the same starting-point developed his system of Idealism.

Matter, according to Berkeley, was no more than a collection of ideas. It had no reality beyond our perception of it. Its *being* was *being perceived* and no more. Nothing was left when we stripped from the thing we were perceiving all the qualities we had perceived. The reason why it did not vanish when we left off perceiving it lay in the fact that the idea of it was always in the mind of God, who had good reasons for communicating that idea to us when it was necessary that we should think of it as real. The act of creation consisted in God's willing that those things should become perceptible to other spirits which before were known only to Himself. Our imagination, unassisted by the Divine Idea, was responsible for our dreams and for our recognition of things as unreal. Berkeley did not say, it must be noted, "There is nothing there." What he said was: "The something which you think is there has no substance, it is purely mental."

And this is the conclusion, though not always presented with the same theological bias, which other idealists put forward. Mind, whether it be the Mind of God or the Mind which is the summation of all minds in the universe, is by idealists asserted to be the only reality. They do not tell us that that which we have thought of as matter does not exist, that the world is a dream or a mirage, but they tell us that what we think of as Matter is not Matter at all. Matter, in the sense in which we conceive it to be an independent substance, does not exist; all that exists comes from mind and mind alone.

Hume.—Hume's (1711–1776) original scepticism, however, directed itself upon the nature of Berkeley's assumptions concerning Mind and penetrated the supposition that Mind is a single entity and agent of all the phenomena of consciousness. What grounds have we, asked Hume, for attributing our momentary perceptions to a permanent Self or Ego ? We cannot strictly say "I know"; all we can say is "something is being known," for we do not know that the something which perceives at one moment is the same as that which perceives at the next. Hume laid the foundations of modern psychology, which is concerned with the investigation of the conditions and phenomena of consciousness without the *a priori* assumption that there is a single underlying Mind-substance of which the phenomena are but facultative manifestations.

Scepticism thus hung like a millstone round the necks of metaphysical speculation until Scottish Realism came forward to liberate her. Practical common sense, in short, turned the tables upon scepticism. Why doubt the evidence of our senses ? Such evidence is as old as, or older than the hills; before philosophy was, common sense existed. It is futile to discredit her testimony. We must rest content with the world as we know it. Metaphysics in its ontological sense, as the study of being as pure being, is absurd. So said the Scottish philosophers, chief among them being **Reid and Hamilton**, who are associated respectively with two different doctrines of dualistic realism.

Meanwhile in Germany, **Kant** was working to answer the scepticism of Hume and to reinstate metaphysics in a different way. Reinstatement is perhaps a misleading term, for what Kant did in his great work, *The Critique of Pure Reason*,

was to limit metaphysical inquiry to bounds which reason herself prescribes. Agreeing that a knowledge of things as they are in themselves was quite unattainable, Kant referred the knowledge we *do* have of relations between things and our senses to principles of cognition and co-ordination which come from the mind. Our conceptions of Time and Space are not given us by sense; they are *a priori* forms of perception involved in the nature of the mind itself. And the object as we perceive it in Time and Space becomes the object we know by reason of the operation of the categories or synthetic principles of the understanding upon the mere chaos of sense. In other words, we weave that which the senses give us into things as we know them by these *a priori* principles of understanding. Mere sense would be chaos without the existence of these central principles which make that chaos knowable.

The existence of the *categories*, or synthetic or connective modes of knowing, makes apprehension knowable. "Perception without notions," said Kant, "is blind"; these notions which combine and clarify the data of the senses are not given by sense, they live in the mind and are ordained by Reason. In the transcendental logic of the *Critique*, Kant sets forth the four forms of judgment, *Quantity*, *Quality*, *Relation*, and *Modality*, from which he derives his categories. These categories which Kant found by analysis to be determinants of all experience must be accepted, he declared, as transcendental knowledge. It is knowledge for the truth of which there is no abstract proof; the proof rests in the fact that without these principles of synthesis we could not have the experience we do have. Beside the categories Kant posited three ideas of pure reason as prior to all thinking, the *Self*, the *World*, and *God*, reason resisting any denial of these ideas. It was from their directive influence that Kant built up his system of morals.

From this point of view, the world as we know it becomes an ordered and comprehensible world, but since its form is absolutely determined by the *a priori* constitution of the mind of the knowing subject, it is impossible to tell what relation it bears to the real world which Kant calls the noumenal world in contradistinction to the phenomenal world of our knowledge. For, owing to the peculiar activity of the mind which moulds the chaotic data of the senses into forms of its own we are forever cut off from a knowledge of the noumenal world. Everything is so altered by Mind that we can never know the noumenal; it has no connection with the objects of sense. It must remain only that which can be thought.

Kant in this way destroyed the notion of metaphysics as a science which could ascertain the nature of Reality, but since he conceived Reality as something-in-itself distinct from the objects of sense, his distinction cleared the ground for a more rational conception of metaphysics.

To conclude this short sketch of metaphysics with Kant may seem to pretend that contention has ceased in the ranks of metaphysicians since Kant's time. Such is not at all the case. Both in England and in Germany, but more especially in Germany, there have been retrogressions from as well as developments and transformations of his doctrines, chief among the latter being the idealistic systems of **Fichte**, **Schelling**, and **Hegel**, and the realism of **Schopenhauer**. But Kant marks an epoch in metaphysical inquiry, and a discussion of succeeding theories at this early stage of the reader's acquaintance with metaphysics would merely blur the problem, as these few pages have tried to give it in its most essential outlines.

Relativity and Subjectivity of Knowledge.—A halt here also enables us to return, as it is important we should return, to the question at issue between Kant and what has been referred to too summarily, and because summarily perhaps misleadingly, as the view of the common-sense philosopher.

This view must not be confused with the average man's conclusion that all metaphysical speculation is so much waste of time since its conclusions make no jot of difference to practical living. Such a conclusion generally springs from an inveterate hatred of reflective thought of any kind, or at least of reflective thought which is barren of practical results. The common-sense school of philosophers have not shirked reflective thought, the first essential to philosophical activity, nor do they esteem it according to its practical results. Their appeal to common sense has come in only in their opposition to the subjectivity of Kantian doctrine when it isolates the thing as we know it completely from the thing in itself. It protests against the truth concerning the relativity of all our knowledge being used to press home the conviction that such relative knowledge inevitably *conceals*, in the active sense of the word conceals, the real nature of things. That such relative knowledge is only part knowledge, it admits, but it can see no reason why it should be assumed that we, the subjects of knowledge, should be so utterly out of harmony with the real natures of things that our relative knowledge must always be considered as a distortion, instead of an approximation, of their real natures.

Kant, as we have seen, urged the relativity of our knowledge as other metaphysicians had urged before him and as the common-sense philosophers did not dispute. But Kant was concerned to prove that such relativity was a *peculiar* subjectivity, that the forms in which we see things were determined by our *a priori* perceptions and categories, and could no more

be considered as *in* the things themselves than can the lantern picture be considered *in* the screen on which it is projected. "We know nothing more than our modes of perceiving them (*i.e.* the things) which is peculiar to us." "This cognition of our own mode of perception remains *toto cœlo* different from the cognition of an object in itself, and that even though we should look the phenomenon through and through to the very bottom."

And this very exclusive subjectivity, this reference to the subject as the sole source of all which made experience possible, experience being what we put into the thing and not a contribution from the thing itself, led not only to the idea of the thing-in-itself as a remote, inaccessible abstraction but also to an almost exaggerated conception of the inevitable, one might even call it intentional, delusiveness of the appearance of the thing. It was against this readiness to declare the appearance as undoubtedly delusive that the commonsense school set itself.

"You must admit the doubt of such delusiveness being so certain"—they said—"since we do not know what the thing-in-itself is, you cannot logically assert the impossibility of its being the thing as we know it." "To declare positively that our relative knowledge is delusive in the most extreme sense of the word, that far from giving us only certain phenomena of the real thing, its purpose is to throw us off the scent altogether, is unreasonable."

Moreover, from the common-sense philosophers' point of view, the idea of the thing-in-itself being entirely apart from the thing as we know it, is a travesty of the original philosophical creed that things are not what they seem and mocks at all instinct for knowledge.

An impasse of absurdity, they argue, is reached under an elaborate relativism which in addition urges "peculiar" subjectivism, which makes the very act of seeing, the very act of apprehending, in themselves fatal prohibitions to knowledge. Hence they conclude that that unknowable reality which is so separate from the thing as it is known as to elude all process of knowing does not exist except as a mere abstraction. They do not conceive the ultimate reality as something transcendentally apart from the world as we know it, but rather something, without a knowledge of which not even the world as we know it can be said to be fully known. The full knowledge of a thing, they maintain, is its metaphysical reality.

Our knowledge can never be more than relative. The possession of additional faculties, though it may be supposed that they would extend our knowledge in as far as hitherto unknown aspects of existence would through these additional faculties become known to us, would still not make our knowledge the less relative. All that we know is, and can never be more than phenomenal of the unknown.

This issue, the relation of our experience to reality, has been the issue on which many modern philosophers have parted company with the older metaphysicians. Kant's searching analysis of the processes and constitution of knowledge, while in one way it took the sting out of the old scepticism by discrediting the grounds over which it had roamed, in another way gave rise to a new scepticism which attacked the problem, as we have seen, from a different angle. It may or may not be due to Kant, and to his reminder of the limits of human knowledge that nowadays Materialists and Idealists seem to fight out their battles at closer quarters. It may savour too much of the average outlook to remark that the old assumed distinction between Matter and Mind seems to be resolving itself more and more into a question of terms. The tempers of all combatants seem to have been modified by the recognition to which science has led them, of the difficulty of declaring with any finality what matter ultimately is even in relation to our senses.

PSYCHOLOGY

The preceding pages on metaphysics will at least have impressed one truth upon the reader, that of the relativity of our knowledge. We know things only as they are in relation to ourselves. Our experience is always relative. We can never eliminate the subjective factor. But just because this factor is constant throughout our experience, so, its presence does not affect the relationship between different forms of our experience, the factor of relativity in the numerator cancelling that in the denominator. Thus we are able, for practical purposes, to view things and the world in an objective way, always remembering that the things and the world we view are not of course the things-in-themselves and the world-in-itself. This is what is meant by saying that we take things as we find them.

But within this objective, or, if we wish to be strictly accurate, comparatively objective, circle of our experience, there is a standpoint of subjective experience which is the standpoint of psychology. The psychological point of view views the world of experience only in its relation to the subject of experience; it is an entirely different standpoint from that of natural science which looks upon experience as taking place independent of the subject. In the pages on metaphysics it was pointed out that the feeling of duration is a very unreliable guide to the measurement of time by the clock; this example illustrates the difference between what are meant by the objective and the subjective standpoints. Physics deals with objective time; psychology is concerned with subjective time, or in case this way of putting it should lead the reader to suppose that physics and psychology deal with two different things, it is better to say that physics looks at time objectively, psychology considers time subjectively. The difference is not a difference in subject matter; it is only a difference in standpoint.

Again, one person's sense of duration may compare most unfavourably with another person's sense of duration. One person's notions of a warm day, of a long walk, of a quiet evening, may differ considerably from another person's views on these points. *It all depends upon the person.* That is the crux of the matter. And it depends so much upon the person that if the person were not there for it to depend upon, strictly there would be no such thing as warm, or cold, or long or short, or noisy or quiet, at all. What would be there, what *is* there, objectively, are various wave-motions, or at least the latest scientific hypothesis is that wave-motions, of different kinds, are the ultimate, irreducible, elements of natural phenomena. Pure science knows nothing about warmth or cold, length, breadth, noise or quiet. She has units of space, time, and mass, but warmth, cold, noise, quiet, &c., are terms implying relationships between the experience and the person who experiences.

The Field of Psychology is coterminous with the world of experience. Every single natural phenomenon is an object of psychology. The material of psychology, in its objective essence, is the same material which all the natural sciences consider from their respective standpoints. The nature of the standpoint from which psychology views the world constitutes the difference between it and the natural sciences. Until we grasp this fundamental issue between the natural sciences and psychology, we shall flounder forever in the attempt to define its province satisfactorily. It has been neglect of this issue that has been responsible for the time wasted in attempts to settle, not only what is psychology's province, but by what clear and comprehensive title that province shall be called. Such attempts may be likened to the attempts of a man, wearing rose-coloured spectacles, to locate exactly, as he looked around him, the difference between the ordinary landscape and his coloured view of it. It is not a question of location at all, as he would soon discover, but a question of taking off, or putting on the spectacles. It is a question of point of view.

The relationship between the points of view of psychology and natural science is a complementary relationship. Natural science considers experience without any reference to the subject of experience, that is to say, it deals with things as they are when the subjective factor which is present in all experience has been as far as possible eliminated. *Immediate experience, containing the subjective factor, is the sphere of psychology.* The difference between immediate and mediate experience may be seized more clearly if we recognise that in all actual experience there are two factors, the object presented to us and our apprehension of it. The object of experience, considered as independent

of our apprehension, is an abstraction; our experience of it is mediate.

Our immediate experience is the object thought of in terms of our apprehension, thought of as dependent upon the experiencing subject. Psychology therefore is supplementary to natural science which deals only with the immediate aspect of experience. Knowledge of the immediate aspect of experience is indispensable to the full knowledge of experience, which is analysable, as we have seen, into an immediate and amediate content.

Also psychology is necessarily the foundation of all those sciences which treat of the various activities proceeding from immediate experience, such as sociology, political economy, philology, &c., because psychology deals with the general and universal forms of experience thought of as dependent upon the experiencing subject.

The Meaning of Mind.—This definition of the subject matter of psychology as the whole field of experience looked at from the standpoint of the experiencing subject, may seem very strange to the average man who has probably hitherto contented himself with defining psychology as the science of mind.

In metaphysics a great deal has been said about Mind, and Mind has been talked about as if it were a single entity responsible for all the processes and phenomena of consciousness. It may seem therefore that to define psychology as the science of Mind is perfectly consistent and sufficient.

But, as Hume pointed out, we are not entitled to speak of mental life in such a glib and summary fashion. We have no right to integrate a continuous flow of perceptions into a single, underlying mind-substance. If we use the term "Mind," we must remember that it denotes not a permanent mental substance, but the summation of all our mental processes. Also we must beware of regarding the sum of our mental processes as a mass of objective things existing, as in early days the soul was thought to exist, independently of our bodies. We must take warning by the example of the man with the rose-coloured spectacles and satisfy ourselves that we cannot lay down objective boundaries for the region of Mind. The term "inner experience" which some psychologists have tried to find sufficient for comprehending the material with which psychology is concerned, fails in exactly the same way as every other definition which by assigning a particular province to psychology creates a dual objective division of our general experience. It suggests that the objects of inner experience are different from the objects of outer experience, whereas no such classification of the objects of experience can be made.

Mind is not an objective thing; all we know about it is that it is conditioned by, and only, under the present conditions of our knowledge, explainable and understandable in terms of objective things, bodily processes, which give rise to that which conditions it.

Mental Processes and Bodily Sensations.—Now what is the connection between our mental processes and our bodily sensations? Most people agree that there is a connection, but while the common-sense view is that this connection is of the nature of interaction, our bodily sensations influencing our mental processes and vice versa, psychologists reject this account of what takes place.

First of all, interaction, the influencing of one thing by another, implies a separation of mind and body for which there is no warrant but the loose notions of an antiquated common-sense. It implies, for instance, in the case of a child who has been frightened and is crying, that the mental distress *caused* the tears. In ordinary conversation, of course, no one would criticise the remark that the child had been frightened and was consequently crying, because language permits us, if indeed it does not encourage, a certain licence and it would be pedantic to inveigh against the expression as an inaccurate one. But when such a remark is put forward as an exact description of fact, psychology is bound to criticise. We do not as a matter of fact know any more about what has happened than that the child is frightened and is crying. Strictly there is no consequence about it at all, as far as we know. Our verbal expression of the facts would be more in accordance with the extent of our knowledge if we were to throw away the conjunction "and" between the statements, break up the sentence into two separate ones, and say the two sentences in the same breath!

For, as far as we actually know, we are confronted with two different phenomena, the mental condition of being frightened and the physical condition of crying.

The experience considered objectively resolves itself into physiological changes, particularly noticeable in the nervous system, brought about by the action of physical stimuli from without. The subjective aspect of that experience is the consciousness of fear. The mental condition and the physical condition are parallel aspects of the one experience, that is to say, consciousness is the subjective aspect of the nervous changes which made the child cry.

Psychology is the study of this subjective aspect of experience which a hasty common-sense has hitherto called Mind, conceiving Mind to be an immaterial substance, existing objectively though radically different from matter, but beyond asserting its immateriality and its radical difference from matter, attributing to it all the properties which material

substances have, among them the capacity to influence and be influenced by Matter itself. The attribution of such material properties to Mind is highly inconsistent with the notion of its radical difference from Matter, and psychologists escape from the embarrassments of these contradictory presumptions by adopting the doctrine of *psycho-physical parallelism*, that is, the view that all mental processes are accompanied by physical processes. Mind, for the psychologist, becomes the sum of human experience under its aspect of dependence upon the experiencing subject, who is a living body equipped for the transmission of experience to the brain with a highly sensitive nervous system. That bodily experiences are conditional to mental life has for long been universally accepted, also that in those bodily experiences, the brain and the nervous system play the most important part. The study of the structure and functions of the nervous system and of the brain during the last fifty years has completely demonstrated the fact that our perceptions of things are entirely conditioned by the impressions which those things make upon our sense organs and by the connection which the sensory nerves afford between the sense organs and the central nervous system, also that mental processes are dependent upon brain processes. Injury to the brain can result in complete cessation of consciousness, while if the nervous system is not intact we have no consciousness of bodily sensations at all.

Moreover, it has been proved that only through the agency of the brain and the motor nerves which communicate between the central nervous system and the muscles are we able to move our bodies at all, or to do anything in the way of demonstrating our existence to other people.

So that without going so far as to assert that bodily processes are the cause of mental processes, there is complete justification for the assertion of *the correspondence between mental processes and bodily processes*, and for the explanation of those mental processes in terms of the parallel physical accompaniments, since mental life is so bound up with and conditioned by nervous processes that a knowledge of the former cannot be understood without a knowledge of the latter.

This conclusion has by some physiologists been stretched to what is known as the *automaton theory*, which assumes that we are merely conscious automata, that the nervous system, *per se*, carries on the work of intelligence, that all our perceptions, volitions, and feelings are merely indicative of physical changes, and do not as such affect our conduct, being no more than inevitably determined items in a casual series of nerve actions.

To discuss the validity of this theory is not relevant to the aims of these few pages. The automaton theory has been referred to simply as affording by contrast a clearer view of the extent of the generally accepted assumptions of psycho-physical parallelism, which do not involve automatonism. Psycho-physical parallelism does no more than posit a correspondence between mental and physical processes, and the realisation of this correspondence is sufficient to point out the indispensability of a knowledge of the physiology of the brain and nervous system to the modern psychologist.

Soul and Body.—It is difficult to throw aside the dualistic notions of common sense. Our everyday thoughts, our poetry, our religion, even our philosophy during periods of its development, have encouraged the belief that we are made of an immaterial self enveloped in a material body, an outer man directed by an inner self, a soul inhabiting an earthly tenement. In early times, the soul was looked upon as a distinct entity or spirit, differing only from the body in the quality of its substance which was thought to be some vaporous, intangible material, capable of slipping in and out of its substantial habitation, the body, and perfectly able to exist on its own account. The old-fashioned pictures of ghosts bearing every semblance to the bodies from which death has separated them, except that they are made of a thin, transparent, bodiless substance, are faithful to this conception. We find the same conception, or at least the main principle of the conception, in the hymn lines "Soul and body reunited, thenceforth nothing shall divide," implying the notion of the soul as a separate being.

This notion of what, judging from the properties attributed to it, must be called a material soul, did not, however, persist among psychologists for long, though ordinary thought continues even in these days to be largely influenced by it.

Psychologists from the time of Aristotle, whose diffidence on the question as to whether the soul existed before and after death, detracted from the consistence of his view of the soul as expressing itself, or being expressed by the vital functions of the body, avoided as far as possible the question of its connection with the body and contented themselves with emphasizing the purely intellectual qualities of the soul.

Many people consider that Descartes' conception of the body as a self-sufficing machine, capable of performing all the ordinary functions of living, put the crowning touch to this theory of the separation of soul and body as concerned respectively and to the complete exclusion of one another with the mental and physical activities, but in so doing they are apt to ignore the very great stimulus to modern psychological thought which Descartes' theory gave.

For though Descartes assigned the higher acts of man to an independent soul he inter-

preted such intelligence as manifests itself in animals, an intelligence which we shall see when we examine the definition of "mind" or "consciousness" is covered by that definition, in terms of physical processes. And seventeenth and eighteenth century psychologists, in rejecting, rightly, this very arbitrary distinction between men and the animals, took the turning to automatonism, and instead of using Descartes' preliminary reasonings as a basis for considering animal intelligence as indicative of consciousness and thereby arriving at the present-day conclusion that the study of animal consciousness falls legitimately within the scope of psychology, rejected the existence of the soul altogether, and attributed the whole mental life of man to a mechanical process of the nervous system.

Kant's reinstatement of the soul can hardly have satisfied any but those who, against the prevailing scepticism, believed in it before, and modern psychologists have long discarded the ambiguous ideas that the word "soul" implies.

The Idea of the Soul.—In spite, however, of all the vicissitudes through which the idea of the soul has passed, the old traditional view of it is still reflected in ordinary opinion. Ordinary opinion is generally a century or so behind scientific opinion in philosophical matters, and the ordinary or common-sense opinion of to-day has not yet emancipated itself from the dualism of the Middle Ages. It still adheres to the belief that man is made up of two distinct things, soul and body.

The security of such a belief has, however, rested upon an artificial seclusion from facts; a rigorous bodyguard of dogmatic assertions has protected it from questionings.

When once we begin to question, the notion topples. It cannot even clothe itself in precise language. It cannot answer simple questions as to the boundary line between the two things, body and mind, as to where body begins and mind leaves off, as to the power which each has, on its own assumption, to act independently of the other, as to the quality of our mental experiences, why we should remember certain things and forget others, the things we remember being sometimes far more distant in time than the things we forget and in no way ranging themselves according to any obvious degree of importance. It cannot tell us why we should feel on some days quite "unlike ourselves," to use a common expression;, it cannot explain the gulf which we feel, sometimes, separates our selves of to-day from our selves of yesterday or of years ago. It offers no clue to the discovery of why in moments of excitement we lose all feeling of self, forgetting ourselves, losing ourselves—Where and How? Why are our lives so intermittently personal and why does the feeling of personality fluctuate from strength to weakness? These are questions that must remain, as far as common sense is capable of answering them, unanswered.

The more we question, the more insufficient to cover the facts of the case does the dualistic explanation become. We realise that it is impossible to assume that our physical and mental experiences are respective manifestations of two separate things, matter and mind, and that any attempt to draw a boundary line between the one and the other results in hopeless confusion, contradiction, and failure. We realise too as we look into our own minds that we must surrender the assumption of a permanent and unchangeable mind within us which the dualistic theory involved, that instability and change belong just as much to mental as they do to physical processes, that consciousness is but a phase of the onward flowing stream of Mind. The identical phase never occurs. All things are in constant change and analysis of mental conditions shows consciousness to be as susceptible to disintegration as matter is, and as subject as matter to laws which can be known, being discoverable from careful observation of all the phenomena and conditions of consciousness. It is important before going any further to get a clear idea of what is here meant by consciousness. **"Consciousness,"** by many people is accepted as meaning "self-consciousness," that is to say, the mind's knowing that it knows, the "immediate knowledge which the mind has of its sensations and thoughts." But the terms of this definition involve us in some of the same difficulties as does the definition of psychology as the science of Mind; it is harking back to the old theory that mind is a complete entity, a stable inner self. Moreover such a definition would limit psychological inquiry to oneself, since it is only by analogy that we can infer the existence of self-consciousness in other people.

Modern psychologists, on the contrary, take "conscious" to be synonymous with "mental processes"; they speak of consciousness being present so long as there is evidence of mental processes going on. The existence of mental life does not permit us to infer the existence of an accompanying self-consciousness in babies, we cannot justifiably presume the existence of self-consciousness though mental life is undoubtedly there.

Many psychologists in order to avoid the pitfalls connected with the use of the word "consciousness" have rejected it altogether and instead have substituted "behaviour," taking as the criterion of behaviour the appearance of any deliberate aim overruling the mechanical processes of organic life.

Behaviour.—But the use of "behaviour" may tend to make us exclude all those actions which, though originally proceeding from purposeful motives, have by habit become almost auto-

matic and are labelled instinctive or reflex actions. There seems no sufficient reason to reject the term "consciousness" so long as we remember that it does not imply "self-consciousness," and include within its scope all that cannot be positively affirmed to show mere mechanical causation.

Professor William James says, in his *Principles of Psychology*: "The boundary line of the mental is certainly vague. It is better not to be pedantic but to let the science be as vague as its subject, and include such phenomena as these (machine-like purposive acts) if by so doing we can throw any light on the main business in hand. At a certain stage in the development of every science a degree of vagueness is what best consists with fertility. On the whole, few recent formulas have done more real service of a rough sort in psychology than the Spencerian one that the essence of mental life and of bodily life are one, namely, the 'adjustment of inner to outer relations.'"

This counsel to caution in definition only affects, however, our exact delimitations of the boundaries of psychology; it should not disturb our confidence in the validity of the essential criterion of consciousness, *i.e.* to quote again from Professor James, "that no actions but such as are done for an end and show a choice of means, can be called indubitably expressions of Mind."

Consciousness in Animals.—Such a criterion of Mind immediately enlarges what perhaps has hitherto been our view of the scope of psychology. We have perhaps limited consciousness to the consciousness that is in man, and though we have assumed that we are justified in attributing minds, similarly constituted to our own, to other men, we have not considered the possibility of mind being in animals. But actions showing purpose and implying choice of means certainly characterise the higher animals. To take only a few examples. What else but volition, the ability to choose, implying the subordination of mechanical action to purpose, is apparent in the attitude of the wary mouse to the trap, in the devotion of the dog, in the behaviour of the stubborn horse? The fact of using such adjectives as "wary," "devoted," "stubborn," in connection with animals, implies that we have had sufficient experience of their unmechanical conduct to enable us to attribute to them qualities whose existence in human beings has always withstood the attempt to regard man as a mere automaton. The writer of a recent article on Ravens in *The Times* says: "Do but go and watch the ravens in Regent's Park for half an hour and you will carry away an impression of alert and cynical intelligence, of impish activity, and of downright unabashed original sinfulness, which will make it impossible for you ever afterwards to say that crows are possessed of unreasoning instincts."

Moreover, we know from a study of animal physiology that the nervous system of the higher animals is in principle like our own, and that even low down in the scale of animal life, among such creatures as the jellyfish and the sea-anemone, there are the elements of a nervous system, consisting, it is true, of no more than a few nerve fibres connecting a few sense organs with a few muscle fibres, but forming, nevertheless, a very simple kind of nervous system. Even beyond the limits of a rudimentary nervous system, there are still creatures whose actions we cannot positively affirm to be mechanical. And in the processes of cellular development in the lowest kinds of animal life, and even in vegetable life, such marvellous adaptability to accident and change of environment are shown, that an analogy between such processes and typically purposeful ones is forced upon us as quite probable, and we find it difficult to stop short of any form of organic nature in declaring the farthest limits of the range of mind.

So that animal psychology becomes a necessary division of General Psychology. The method of observation is necessarily indirect. The animal consciousness has to be built up by analogy, that is to say, by interpreting the movements and gestures of animals in terms of what such movements and gestures would imply if they were human movements. This method of interpretation by analogy is not, of course, confined to animal psychology. In those special branches of psychology which are concerned with the abnormal consciousness during permanent or temporary mental derangement, such as insanity, drunkenness, hypnotism, &c., when the subject is in no position to give direct assistance in the investigation of his case, analogy has very largely to be relied upon.

Methods of Psychology.—The methods of psychological investigation do not differ from the methods of any scientific study. There is no fundamental difference between looking without and looking within. Only unfamiliarity with introspection, which is the name given by psychologists to looking within, or unfamiliarity with conscious introspection (for our very language is soaked with subjectivity, and we are normally introspective without knowing it) makes it seem a novel, an unreliable, and because of its unreliability, a dangerous instrument. How often do we not hear "introspective" applied scornfully to the unpractical dreamer? How often is it not assumed that introspection is but another name for unmethodical musing? These are merely instances of how common parlance debases the proper meaning of words.

Introspection requires just as much mental activity, just as much keen and attentive

observation, as does the more familiar inspection. The same differentiation as we employ in judging the value of inspection, we employ in accepting the results of introspection. Attention, a clear mind, the power to give a clear account of our impressions, are as indispensable to the one as to the other. But though the introspective method does not differ fundamentally from the ordinary method of inspection, there is a very great difference in the nature of the objects of inspection and introspection.

It is very difficult to get the thing as we see it objectively out of our minds; practical life is against our seizure of the subjective impression, habit tends to make us ignore all that does not correspond with the objective conception of it.

Education until lately has been only in the direction of training us to a quicker grasp of what things are objectively. Subjectivity has been dismissed as pertaining to the morbid, and as likely to lead to hesitant action.

The grounds for such a contention have obviously been that subjective knowledge must be unreliable inasmuch as it depends upon a view of things conditioned by the peculiar constitution of the individual. But the results of psychological experiment, even more than sober reflection on the matter, prove that such an assumption of inevitable difference between our subjective knowledges is unwarranted. There is variety in detail but no basic disagreement.

A study of comparative poetry, perhaps the greatest treasury of one kind of subjective knowledge that we have, should make us pause before asserting the fundamentally peculiar nature of subjective knowledge. Religions, superstitions, languages, all strengthen the belief that man's mental constitution is at bottom much the same all the world over. In asking people to study psychology and to become introspective, we are not asking them to abandon standards. Subjective knowledge is as amenable to classification as objective knowledge.

But mental states are slippery things to observe, and particularly in the case of observing emotions, introspection involves an effort of reflection which may arrest or at least modify what we are observing. In such cases, introspection resolves into retrospection; the introspective method can only be applied upon the *memory* of the mental state with a resulting loss of accuracy.

Experimental Psychology.—Consequently, to correct these inaccuracies and to supply deficiency recourse has had to be had to experiment, the second chief method of investigation employed by all the empirical sciences. Experiment means, as we know, ability to control the course of experience and to isolate the various components of the objective content of the experience. The most favourable conditions for observations are secured when the subject is isolated as far as possible from all experience extraneous to the particular experience it is desired to observe, and when, by breaking up the external impression into its component parts, the influence of each single part can be separately noticed. Moreover, experiment permits of the observation of the physical accompaniments of the mental states, so that wherever breaks occur in the continuity of our psychological knowledge the physiological knowledge supplies a parallel explanation of the missing link.

Psychology and physiology must be regarded as supplementary sciences. Our mental processes are conditioned by and explainable in terms of our physical processes. And that the parallelism insisted upon is not a mere verbal device to escape being branded along with the automaton theory as rank materialism, is shown by the fact that introspective psychology won many of her conclusions before physiological observation had entered the field of psychology, and that psychology may justly claim to have filled up, on several occasions, gaps in the continuity of physiological knowledge.

That the theory of psycho-physical parallelism is materialistic is not to be denied, though since our notions of what "materialistic" connotes are mainly drawn from the views of those who, without proof, assert Matter's eternal opposition to Mind, the term cannot be used without risking considerable misunderstanding. All the ideas of grossness, of earthiness in the literal sense, with which Matter is associated in the mind of most people, proceed from the ancient dualistic argument that the world consists of two distinct and separate things—Mind, which is responsible for all that is high, eternal, pure, and noble, and Matter, which is low and muddy, and incapable of any life or nobility whatever, being also slavishly subservient to the laws of external nature, while Mind obeys no laws save possibly some of its own making.

But this view of Matter is incompatible with the theories of those who are called materialists to-day. Physical processes which have been proved to be the inevitable accompaniments of mental, or psychical processes, and by reference to which those psychical processes are explained, have been analysed down to such an incredible degree of refinement that, to use the words of Mr. Herbert Spencer, whose chapter on this question should be read by all who associate materialism with grossness, "there is no trace of grossness left." There is nothing in the processes of material development to offend the sensibilities of the most scrupulous spiritualist.

Modern psychological thought is certainly

materialistic in the sense that it is not spiritualistic, in the sense that it refuses to consider psychical processes as the manifestations of a specific underlying mind-substance, conceived as radically different from Matter, and indeed as radically different to anything which can be conceived. It refuses to be satisfied with a mere description of mental experience which must necessarily be unsystematic, uneven, and disconnected. It refuses to adopt the fiction of a mind-substance independent of experience. It comes to rest, for the time being, in the conclusions of psycho-physical parallelism, which these few pages have tried to present.

ETHICS

Ethics is the Study of Man's Moral Nature.—It seeks to determine the laws of right conduct, it asks what ought to be, and why it ought to be.

At first sight it might appear that the answers to these questions were not difficult to find, but as soon as we begin to consider what is meant by good and evil, right and wrong, we find ourselves in just as much uncertainty as surrounded the question of what is reality. The basis of morality is not by any means fixed, if we may judge by history's records of human conduct. Notions of good and evil have never shown themselves inalterable.

> "They change with race, they shift with space,
> And in the veriest span of time,
> Each vice has worn a virtue's crown,
> Each good been banned as sin or crime."

Views of the Basis of Morality.—Nor does the history of ethical thought present continuity as regards the development of a single view as to what constitutes that basis. It presents only a continuity of that impulse which gave rise to Greek ethics, the very nature of which impulse stands for persistent dissatisfaction with accepted theories.

Greek ethical thought developed from exactly the same conditions as lay at the bottom of Greek philosophic activity. It began by questioning.

Such fragmentary ethical ideas as the early philosophers had expressed in their metaphysical conceptions had never gone beneath the assumption that submission to an unchangeable law or order of the universe must remain the prime ethical motive.

But in the *Sophist* or *Socratic period*, the validity of laws began to be questioned. From realising the mutability and insecure basis of political laws and constitutions which the times showed, men began to reject law in itself as a sufficient basis of validity, and to assert individual judgment in the place of authority. It was Socrates who arrested this movement before it had attained its inevitably anarchical conclusion. Accepting the claim of private judgment to usurp authority, he yet insisted upon the necessity for a standard of private judgment, a standard determined by exact knowledge of the things to which men's actions relate, and by men's knowledge of themselves. Thus ethical excellence, or virtue, came to be looked upon as the knowledge of what is good, and the insight, by which Socrates insisted that the knowledge of what is good might only be attained, demanded not the free play of unbridled instincts, but that prudence and self-control of which his own conduct was such a shining example. Socrates reinstated authority, not indeed upon the old grounds of unquestioning obedience to authority but upon the basis of obedience to insight which recognises authority's validity.

But *Socrates*, in defining virtue as knowledge of the good, resulting necessarily in wellbeing, or, as most translate the Greek word "ευδαιμονια," happiness, had still left undefined the actual content of the good to which insight proceeding from exact knowledge should lead, or at least he had not defined the good in universal terms. Consequently a number of different theories were put forward to accomplish this definition. The most important of these were the Cynic and the Cyrenaic, and diametrically opposed to one another as these two theories were, both bore the unmistakable mark of Socratic teaching, in that both were expressions of a rational mode of living, in contradistinction to conduct guided merely by impulse.

The Cynics, of whom Diogenes (born *circ.* 412 B.C.) is perhaps the most generally known, because the most eccentric, representative, were the followers of Antisthenes, himself a disciple of Socrates, and their main tenet was that virtue in itself was the only good. This doctrine did not imply, as might be supposed, that happiness consisted in doing good for good's own sake, but it conceived happiness as achieved only by a life which is as far as possible independent of all those desires and wants, dependence upon which makes man the unhappy plaything of powers which he can never control.

True virtue, for the Cynics, consisted in abandoning such desires and in living a life which the changing circumstances of the outside world had no power whatever to disturb. Such a conception led to an attitude which not only rejected all the pleasures and even the bare necessities of ordinary existence, and expressed the utmost contempt for conduct which was not imbued with this notion of the worthlessness of such pleasures and necessities, but went out of the way to hasten the arrival at complete spiritual independence by indulging in the most ludicrous excesses of abstinence, excesses

which showed such a coarse neglect of the smallest proprieties that they were labelled "doglike" (*kunikos*) in accordance with the current notion of all that was shameless.

The doctrine of the Cynics was one of complete negation to all society and to all civilisation. They scorned honour, fame, in every aspect of human life. The domestic, political, and national virtues which Socrates had upheld, had no place in their ruthless economy, and the cosmopolitanism which Diogenes professed merely symbolised the universal character of his contempt for society.

Hedonism.—In complete opposition to the Cynical conception of good was the conception of Aristippus of Cyrene, the founder of Hedonism. Pleasure (ἡδονή) was asserted to be the content of the good to which insight led. The truly wise man was he who by insight could secure the greatest degree of pleasure, and, reasoning from the fact that we know things only as they are in relation to our senses, Aristippus concluded that the highest degree of pleasure must lie in sensuous enjoyment. This enjoyment was not, however, to be indulged in without discrimination, for the Hedonists established a policy of choice of pleasures regulated by insight capable of determining whereby the maximum of pleasure with the minimum of pain could be attained, which policy was based upon a physiological theory of their own elaboration concerning the correspondence of certain bodily motions, gentle or violent, with pleasure or pain.

As citizens, though they started from the same point as did the Cynics, of considering all social and moral conventions to be irrational impositions upon free men, the Cyrenaics were not led as the Cynics were, to eschew the advantages accumulated by civilisation, but to accept these advantages without acknowledging any accompanying social or political obligations. Their cosmopolitanism reflected merely their apprehension of the selfish advantages accruing to those who, owning no fatherland, batten upon all.

Plato.—In both of these developments from the Socratic doctrine, it is a noticeable characteristic that the standpoint of the individual's happiness, as distinct from that of the community, is alone considered. In the Platonic development, not only is the individual's good considered as inseparable from that of the community, but the whole conception of ethics is regrounded upon a wider basis. This regrounding is expressed in Plato's great system of idealism wherein, advancing from the Socratic isolation of the inquiry into man's moral nature from the metaphysical, he identified the conception of human good with the absolute good of the universe. All the things of experience, all visible things, were, according to Plato, but imperfect copies of their eternal archetypes or Ideas existing behind the world of sense, with which the wise man after long travail ultimately becomes acquainted.

Man's good was to see this Eternal Perfection of which imperfect earthly particular things were but dim likenesses, guided by reason along the Socratic paths of induction and following the gleam of reminiscence. For Plato expressed his conviction that a love of the good was innate in man, although clouded by ignorance, in an allegory that the soul had in some pre-earthly state seen the sacred forms of the eternal verities.

Aristotle (384 B.C.–322 B.C.), agreeing with Plato in declaring Good to be knowledge in the acquiring of which Reason must be the predominating factor, set forth a systematic theory of morals. Virtues, according to Aristotle, lay in the mean between two extremes—courage, for instance, between foolhardiness and cowardice; truthfulness, between boastfulness and self-depreciation. By practice only could a knowledge of the mean be gained. But Aristotle's ethics, perhaps due to the emphasis he placed upon the necessity of pure speculation, did not in his own day meet with a wide acceptance, and popular moralising again asserted itself in the two last schools of the Greek period of philosophy, the Stoic and the Epicurean.

These two schools, founded respectively by Zeno and Epicurus about the end of the fourth century B.C., presented the ultimate issues of the two earlier antithetical conceptions held by the Cynics and the Cyrenaics.

Stoicism, the name derived from the Greek στοά, or "portico," from which Zeno taught his disciples, maintained with cynicism the self-sufficiency of virtue and indifference to all goods of the outer world, but it advanced beyond the naturalism of the Cynics in attributing to the soul a power to shut itself off from all those excitations of sense which, if not dissented from, invade the man as passions and emotions. The soul by refusing assent to such excitations remains immovable, imperturbable, and virtue consists in ἀπαθεια, the entire absence of emotions. This attitude differentiates itself from the attitude of the Cynic who took an almost boisterous pleasure in undergoing discomfort. The Stoic secluded his soul from the appreciation of pain just as much as from the appreciation of pleasure.

Moreover, the Stoic, in his devotion to duty which, upon a basis of the conception that certain motives "naturally" exist in a purely reasonable state of mind, prescribed guidance for conduct, did not dissociate himself from the community as the Cynic had done; indeed, one of the basic elements of the Stoic conception of duty was the belief that man was "naturally"

a social and political animal, and this feeling of responsibility, this consciousness of duty, gave to Stoicism its finest qualities. "Live according to the demands of Nature which coincide with pure reason" was the Stoic precept, and the spirit of Stoicism is expressed in the prayer of Cleanthes, who succeeded Zeno, "Lead me, O Zeus and Thou Law of the World, whithersoever I am appointed by thee, for I will unreluctant follow."

The Epicureans, on the other hand, maintained the Cyrenaic doctrine that pleasure is the only good, pain the only evil, but they dissented from the early Hedonist view that the essence of pleasure lay in "smooth motion," and placed the condition of painless rest as that conducive to the highest pleasure. A settled calm was all that the Epicurean desired, and this was incompatible with the presence of passions.

Consequently the Epicurean shrank more and more from indulgence in those pleasures which were fraught with emotional or passionate agitation and found his happiness in mental enjoyments, not, however, in such things as ethical or metaphysical speculation, for those might disturb individual contentment, but in the refinements of living, of intercourse with friends, and in the æsthetic interests of a sheltered life.

Compared with the older Hedonism, Epicureanism was in truth a far more refined and cultured form of egoism, but it nevertheless remained egoism, destitute as Cyrenaicism had been of all feeling of responsibility to the community, and presenting a vivid contrast to the Stoic conception of duty.

The ideal of independence of the outer world which was reflected in both Stoic and Epicurean doctrines likewise characterised the scepticism which prevailed alongside these last schools of Greek ethical thought. Suspension of judgment, and hence a condition of "ataraxy," as the only means for the wise man of avoiding false action, was the logical outcome of the union between the Socratic postulate concerning the indispensability of knowledge to right action with the metaphysical conclusion that no real knowledge was possible. This scepticism ultimately pervaded, in varying extents, the teachings of all schools, and explains the foundations of the religious development of ethical speculation which marks the period of transition between the ancient thought and the definitely theological era.

Similarly the content, or rather the intellectual complexion of the content, of Christian theological doctrine is related to this transition period of Greek and Greek-Roman philosophy which in its various phases of Neo-Pythagoreanism, Neo-Platonism, Eclecticism, all strongly marked by the religious motive, centred around the cosmopolitan Alexandria.

When the Church had proclaimed its dogma, further ethical speculation became unnecessary. Throughout the Middle Ages, philosophy was mainly concerned in expounding the metaphysical truth of theology, and ethical problems ceased for the time being to be fundamentally problematic.

Modern English Ethics.—With the Renaissance, philosophy broke from theological tutelage, and Modern English Ethics may be said to begin after the Reformation with Thomas Hobbes (1588–1679).

Freedom of thought, which was the first fruit of the Renaissance, viewed in its aspect of uncompromising opposition to Scholasticism, was, by the exhausting political consequences of that Renaissance itself, turned into a utilitarian and scientific channel for the reach of that quietude and order which all men desired. The reaction against mediæval modes of thought, against mystical aspirations and unpractical enthusiasms, was intensified by the political religious wars of the sixteenth century, and culminated in the sober, unidealistic, unenthusiastic common sense of the seventeenth and eighteenth centuries, which asserted the essential relationship between an ethical system and everyday practical politics. Hobbes, Locke, Hume, Bentham, and the two Mills were successive exponents of the conditions of this relationship.

Hobbes.—Hedonistic egoism was the cardinal doctrine of Hobbes' system. Men's actions, he contended, were ruled solely, first by motives of self-preservation, then by pleasure-seeking instincts. The natural state of mankind was a state of war in which each man fought for his own life and his own pleasure, to stay which horrible conflict, men entered into a contract for mutual forbearance and government. Only by such a contract could the individual ensure his self-preservation and the satisfaction of his desires; the recognition of the social standard, of the rights of others, proceeded directly from the egoism which sought first and foremost to secure its own rights, and saw in the idea of a contract the best way of achieving its ends. But that contract had to be inviolable, else it failed of its purpose; hence the necessity for an absolute government.

From such premises, all moral goods were traced back either to the original, untrammelled egoism, or to the resultant social agreement. Hobbes is most consistent in his reference of every single emotion to egoistic motives, pity, for instance, arising from the individual's fear of having to undergo the suffering that the object of his pity has undergone, benevolence being prompted by the hope of a returning benefit. The beautiful is defined as pleasure in promise. In some way or other, the idea of personal profit conjugates itself without

exception throughout men's actions and attitudes.

The foundations of such a theory of egoism were immediately combated. Hobbes had made morality the outcome of social institution, its sanction lying in its utility. Ethical aspirations were denied any original existence.

This was the issue between Hobbes and the Cambridge Moralists, chief of whom were Cudworth and More, and after them, Clarke, and it has been the issue ever since between the Utilitarians and the Intuitionists.

For the Intuitionists, the moral order is an intuitive certainty, eternal and immutable, proceeding, not from social institution or the will of a sovereign power, but from an original moral faculty. There is no relativity about right and wrong at all. The social instincts are as innate in man as the individual instincts. The religious instinct similarly is innate, as independent of revelation and dogma as it is of social institution.

Cumberland and Locke.—A second issue of the controversy started by Hobbes was presented by Cumberland (1632–1718), and Locke (1632–1734), who were concerned to explain morality as obedience to a code of Divine legislation.

Cumberland was the first to declare that the common good of all should be the standard for moral action, yet he does not explain very clearly how it is that individual action is turned in the direction of altruism.

Locke maintained that the measures of this divine sanction could be empirically determined, and though he does not definitely point to altruism as its cardinal principle, his writings tend to show that he so considered it.

But Locke's empiricism and his determined opposition to the theory of innate ideas held by the Intuitionists was not based upon Hobbes' conception of a conventional morality. Locke denies, it is true, that innate ideas are original in the mind at birth, but he nevertheless holds, in opposition to Hobbes, that the moral order has a sanction entirely independent of political society, a sanction which he conceives to be a divine one, "whereby good and evil are drawn on us from the will and power of the law-maker."

Lord Shaftesbury.—After Locke, and Clarke, who wrote to present the self-evident nature of the dictates of morality, a second period of opposition to Hobbes, a period of psychological analysis into the Hobbesian egoism, was ushered in by Lord Shaftesbury, the author of *Characteristics* (1671–1713). This psychological trend of ethical thought was but one aspect of the predominant intellectual characteristic of the eighteenth century to ground its knowledge upon the study of man himself, which Pope, speaking for his times, declared to be mankind's proper study. Philosophy reflected this tendency just as much as literature and all aspects of intellectual life, and psychological experience from this time onward became the recognised basis of ethical inquiry.

The egoism of Hobbes, according to Shaftesbury, was a very imperfect and superficially conceived egoism, an egoism which artificially isolated the individual interest from social affections and conceived man to be a wholly unrelated individual. Shaftesbury maintained the social instincts to be as innate as the individual instincts, to be, in fact, *part of* the individual instincts, that "to have the natural affections, such as are founded in love, complacency, goodwill, and in sympathy with the kind or species, is to have the chief means and power of self-enjoyment, and that to want them is certain misery and ill."

Shaftesbury distinguishes between what he calls the "natural affections" and the pure self-affections, and maintains that perfection is reached by balance, an harmonious adjustment, between the two sets of impulses. Renunciation of all self-affections is as great an obstacle to complete self-development as is undue indulgence in the natural affections. Individualism straining to perfect development is the keystone of Shaftesbury's theory of ethics; ethical judgment partakes of a cultured adjustment of conflicting motives.

Bishop Butler (1692–1752) gave a severer and more dogmatic outline to the line of thought initiated by Shaftesbury, and developed on Shaftesbury's lines by Hutcheson. His religious temperament could not assent to what may be called such an æsthetic solution of the moral problem. He is rather fearful of leaving self-interest, even an enlightened self-interest, and the benevolent feelings to fight it out undeterred by more authoritative considerations, and he insisted upon the regulative influence of conscience, whose claims were paramount. Conscience regulated the balance between motives as she regulated the action of those motives themselves. But Butler, like so many Intuitionists before and after him, still left the problem of in what consisted that paramount sanction of conscience unsolved; he asserted, though he did not explain, the moral intuitions. And in this omission to explain the moral intuitions lay the weakness and the incompleteness of the Intuitionist argument. Hitherto the most explicit attempts to get beyond the conventionalism of Hobbes in defining the nature or principle of the sanction for morality had yet based its force upon man's recognition of the consequences of reward and punishment attached to obedience and disobedience, and in so doing had merely substituted a refined, but not less egotistical obligatory motive for the cruder one.

In **Hume** (1711–1776), we see that refinement of the *egoistic motive* carried almost to its dissolution into *altruism*. Sympathy, the indi-

vidual's ability to feel with others in their pleasures and pains, must be considered as the impulse to moral action. Adam Smith developed this theory of sympathy still further till with Bentham (1748–1842) and J.S. Mill (1806–73), the founder and the great exponent, respectively, of modern Utilitarianism, the principle of the greatest happiness of the greatest number is positively adopted as the principle of moral action.

Bentham's system was based upon the assumption that it is possible to determine the pleasurable or painful consequences of actions in quantitative terms, the determining elements being intensity, duration, certainty, purity, fecundity, and extent (meaning the number of people concerned). His ignoring of quality apart from intensity is expressed in the famous statement "quantity of pleasure being equal, pushpin is as good as poetry."

On this basis, he made the most rigid quantitative analysis of human action, and demanded that such a computation should always "be kept in view" in arriving at ethical judgments.

Bentham did not ignore the possibility of individual and general happiness not coinciding, but his omission to supply definite guidance in such a contingency was evidently based upon his belief that with increasing use of his computative instrument men would realise more and more how intimate the relation between private and general happiness was until the relation ultimately became an identity.

John Stuart Mill and Utilitarianism.—It was, however, upon the principle of true altruism, with stress upon the repression of personal desires, that Utilitarianism in the hands of John Stuart Mill attained such strength.

Influenced by the humanitarianism of *Comte* in France, and by the fervent austerity of his own convictions, Mill invested Bentham's doctrine with an almost religious grandeur, and secured for it an abiding place in political action.

Moreover, he reinforced the bare, calculative considerations of Bentham by an appeal to sanction which the latter ignored, and claimed that the ultimate sanction of the greatest happiness morality lay in man's "feeling of unity with his fellow-creatures," a feeling which made the demand for harmony between private and general happiness a natural one.

The power of Mill's appeal to the average man lay possibly in its eclecticism, in its blending of the Stoic and Epicurean ideals with the practical ideals of the day. For, adopting the Hedonistic standard, Mill yet preached the Stoic self-sacrifice as the best means of arriving at personal happiness. Also the fruits of political action and the example of his own life inspired by such a creed contributed to men's acceptance of it.

Mill further strengthened his system by reference to the Associational Theory, first propounded by Hartley. This theory accounted for the moral feelings by developing them, through the influence of association and the habitual tendencies which follow from association, from their original positions as means to ends to ends in themselves, in the same way as the miser's love of gold for its own sake is developed from his first love of gold as means to the comforts which gold brings. Thus virtue, from having originally stood in the position of means to the attainment of desirable ends, comes to be loved for its own sake, and the force of habit is strong enough to induce men to pursue virtue even when such pursuit is not likely to result in the ends to which it was originally directed. The Associational Theory has now merged into, or been supplanted by, the Evolutional Theory which lies at the base of Herbert Spencer's monumental system of thought, and which invests ethical judgments with a new relativism, a relativism of actions to ends, wrought by the irresistible, onward forces of universal evolution.

The theory of inheritance from the past, and inheritance ordered by natural selection aiming at the preservation of the species, introduces an additional ground for the maintenance of the broad utilitarian argument, while, at the same time, it removes the standard of happiness from the sphere of immediate definition to a remote region of absolute, objective future well-being.

For the argument of evolutional ethics is roughly this. Morality is in moving equilibrium with external forces. The dictates of morality shift with the ends to which those dictates are directed. All our moral standpoints are relative to certain definite consequences, desirable and undesirable ends, and as the development of life proceeds, human conduct will tend to become more and more adjusted, without any deliberately avowed or moral intention in the adjustment, to the achievement of those ends. The consciousness of performing a moral or an immoral action will fade with mankind's growing nearness to a perfect moral equilibrium until eventually there will be no conscious morality, no self-compulsion, about action at all. Men will perform moral actions without recognising that they are moral, because they will have a clear vision of the identity between duty and pleasure. To quote from Spencer's *Data of Ethics*, "Living together arose because, on the average, it proved more advantageous to each than living apart; and this implies that maintenance of combination is maintenance of the conditions to more satisfactory living than the combined persons would otherwise have. Hence, social preservation becomes a proximate aim, taking precedence of the individual aim, self-preservation." And in the same revolutional way men will ultimately realise that a perfect morality presents to them their sole advantage. It is, after all, the same thing as the theological conception, or indeed any

Utopian conception of an ideal society, "And there shall be no more pain, and sorrow and sighing shall flee away." Only there is this difference, that, as is not always the case with theological schemes and Utopias, the perfect condition will arise naturally, and by no intervention from without, upon a world hoary with sin. The ideals of the individual will find themselves fully realised in the ideals of the state; the distinction between egoism and altruism will be lost, "ought" will present no conflict of interests. Absolute Ethics then, in contradistinction to Relative Ethics, is not concerned directly with the actual actions of actual men. It is concerned with ascertaining necessary relations between actions and their consequences and the consequent deductions as to what conduct promotes the aims of an ideal society. Men's eyes must strain forwards, and not backwards to a pre-existing perfection of which Plato conceived them to have dim memories, towards the ideal of an absolute right in a society yet unborn.

But the **Intuitionist School** had never ceased to oppose the utilitarian and empirical and evolutional premises upon which this theory was built. They combated its conclusions, as they had combated the various preliminary stages of Utilitarian thought, with the same emphasis upon an intuitive moral faculty, the same belief that man as a self-conscious being, distinct from the animals, is possessed of a knowledge of that good which he alone of sentient creatures may aspire to and at last inherit. They could not assent to a theory which viewed human existence only as part of the whole of natural existence, dominated in every aspect by laws applicable to that whole. As they conceived the Supreme Being to be apart from nature, so man, in whose spirit the divine was reflected, was also apart, *free*, by reason of this divine reflection to act, and, choosing his own ends, to reach at last divine perfection.

Starting with *Price* (1723–1791), who may be considered the first of the later Intuitionists which reached its most influential expression in the Scottish School, and is most allied to Kant's great ethical system which, though published in Germany contemporaneously with the writings of Reid, the founder of the Scottish school, was little known in this country until nearly fifty years later, we find particular emphasis laid on the "formal rightness" of an act, unintentional consequences not affecting the merit or demerit of the individual who performs the act. The rightness of an act is essentially independent of ends other than the end of acting rightly, though Price does not deny, indeed he asserts, that the motives of self-love and rational benevolence are right ones.

Reid (1710–1796), unwilling to dissociate moral values so entirely from non-rational impulses, still maintains that "no act can be morally good in which regard for the right has not some influence." This fundamental tenet of all the Intuitionists that formal rightness, apart from other ends, is the essential standard of moral worth, that duty must be followed for the sake of duty, involving the notion of a Will free to resist the promptings of the non-rational impulses and to choose the path of duty, appears in the *Categorical Imperative* of **Kant,** "Act according to that maxim which you can wish to become a universal law."

This *Categorical Imperative* issued by the reason is an absolute command, based on no experience of the connection between end and means which can only prompt a hypothetical imperative such as "If you wish such and such a consequence then perform such and such an action," but self-determined, following a law given only by itself, and as such purely formal. Actions which are willed on account of their consequences all presuppose the act of pure willing itself; this pure willing is dependent upon no empirical experience, no perception of consequences, but upon nothing but itself, it follows its own laws and is autonomous.

That self-determined law must be of universal application. It must dictate a maxim, a *form* of action. Hence the categorical imperative proscribing action which the agent is willing to see universalised. Wrong action is, therefore, that which cannot stand the test of being potentially a universal law. The moral law being universally binding must be capable of universal application. Men's actions, then, must be prefaced by consideration as to whether they could be willed to be universal. Would a man steal if he thought that by stealing theft would become a universal principle? Ethical consideration is not as a rule a habit of criminals, but it may be said that in general they do not desire that the law which they have broken should not bind other people, by whose deference to it they profit. Their chances of success in performing wrong deeds would be minimised if all people, without exception, acted likewise.

From this conclusion Kant deduced the absolute value of the moral law, whose demands are fulfilled irrespective of consequences. Its value lies in itself. It is not for what it does, but for what it is that it compels obedience and respect. Hence Kant's recognition of the dignity of man who obeys that absolute law, man who is its agent and its means of expression. "So act as to use humanity in yourself as in others, always as an end and never as a means."

Kant thence developed a strict, almost forbidding, system of morals; since in his eyes the introduction of unrational impulse as a motive to action degraded the moral value of the action. Duty alone must prompt men's actions. The natural impulses are not in themselves either moral or immoral, but they become

immoral when they prompt the neglect of the moral law. The idea of duty for its own stern sake visualises a relentless Deity, and oppresses the mind with something of the deathly chill which Frederick Myers tells us he felt when walking with George Eliot, the great Positivist, on a rainy evening in the Trinity Fellows' garden at Cambridge, she talked of God, immortality, and duty, and "pronounced with terrible earnestness how inconceivable was the first, how unbelievable the second, and yet how peremptory the third."

But Kant believed in God and immortality, belief in them was with him an a priori necessity, and rested upon the ideas of pure reason which the speculative reason could not touch. None the less his morality is a grim one, partaking of the self-repression of the Puritan and the Stoic.

English grasp of Kantian doctrines was, as before mentioned, a belated one. When she ultimately seized them, Kant was dead, and later German philosophers, of whom Fichte, Schelling, and Hegel were the chief, had transformed Kant's system in various ways.

Hegel (1770–1831), who alone of these three exerted any profound influence upon English ethical thought, and whose teachings are largely reflected in the writings of the Oxford **T. H. Green,** the author of the *Prolegomena to Ethics*, insisted upon the harmony between the Universal Will as realised subjectively in the individual and the Universal Will as realised objectively in the society of which the individual is a member. In the common consciousness, or Sittlichkeit, of the community the Universal Will is realised, and morality consists in the harmony between the subjective disposition of the individual and the demands of that Sittlichkeit, a harmony obliging, if necessary, a subjection of the individual's consciousness of right to the wider objective consciousness. That wider consciousness which is realised in the State cannot be understood without reference to history, which alone can present it in its proper relation to the full manifestation of what Hegel calls the objective spirit of the universe. The history of human thought and human action thus presents an unfolding of the absolute, and every particular stage has its reality in so far as it manifests itself as a stage in the procession of the Whole.

Isolated, a particular thing, a particular action, has no reality. There is no *real* separateness. Only as part of an evolving whole, can things and actions be apprehended as real. And the end of evolution is the awakened consciousness of in what our whole self consists, not in a narrow egoism, nor in a less narrow social self limited by personal interests, friends, and things, but in the whole illimitable environment of physical life. "Realise thyself as an infinite whole, as a member of an Infinite Whole." Such, roughly, was the absolute idealism of Hegel, which has furnished the basis for the transcendentalism of recent times.

It remains now to review this brief sketch of the course of ethical thought from ancient until modern times in order to emphasize, still more briefly, what has been and still is, one of its supreme issues. Distinct from the issue concerning the *content* of Good, as to whether Hedonism, either in its egoistic or altruistic form, either declaring the sole motive to human action to be the desire for pleasure for ourselves or for others, satisfactorily and completely defines that content, there is another issue, the question of the *Moral Consciousness*.

The influence of Thomas Hobbes, the founder of the modern Hedonistic school, or of the tendencies which found their expression in his system, was so far-reaching that the question of the content of Good never, as far as the eighteenth century was concerned, came into the forefront of discussion at all. It lay more or less obscured behind other questions until the great extension of utilitarian thought in the nineteenth century and the elaborate restatement of the altruistic-hedonistic basis by Bentham and Mill reprovoked the original conflict.

Basis of Moral Judgments.—The prominent eighteenth century question was as to the *basis* of moral judgments, as to whether moral judgments were psychologically relative or eternally and immutably fixed. And as there were two main answers to this question, so there evolved two distinct conceptions of the moral consciousness, though not always explicitly expressed in the writings of moral philosophers.

The first conception which lay behind most of the writings of the intuitional school of moral philosophers, and which attained full expression in Kant's Categorical Imperative, was that the basis of moral judgments lay in the Reason, that Reason without any regard to empirical motives decides what is right and what is wrong.

The second conception considered moral judgments to proceed from a special "moral sense" as capable of deciding on right and wrong as the other bodily senses were to decide upon taste, smell, sight, hearing, and touch. Hutcheson, who with Shaftesbury, was the founder of the "moral sense" school, conceived the moral sense to be an original, innate faculty for ethical decisions, and made feeling for the good a kind of æsthetic feeling comparable to feeling for the beautiful.

The significance of these two doctrines is most important. On the one side we have ethical judgments referred to and rooted in intellectual cognition; and resulting in an objective right and wrong, independent of personal considerations; on the other side, we have moral judgments identified with all those judgments which are entirely dependent

upon personal feeling and emotion. Objectivity of right and wrong is at once destroyed. On the one hand, we have a law which is not, in Kant's words, "empirically knowable," which neither pleasure nor pain can alter by a hair's breadth, immensely strong in its absolute independence of empirical considerations; on the other, we have a judgment swayed by transient feelings and impulses, as incapable of being determined save by actual empirical considerations which vary in each individual.

Now it is upon the answers to this question, with its far-reaching destructive consequences in the one case, and its possibilities of construction in the other, that our views of the value of the study of ethics must depend.

The Problem of Ethics.—If we believe that there is no such thing as objective right and wrong, that what is true for one person may be equally untrue for another, that moreover there is no stability about our own personal moral judgments, can we with any sincerity, any hope of finding practical guidance, devote ourselves to ethical study? Is not such study superfluous, since there is no possibility, upon our assumption, of arriving at objective decisions concerning the matters with which ethics deals.

If, on the other hand, we do believe that right and wrong can be objectively determined, that the moral law reveals them to us, then we are justified in our pursuit.

We need not go to ethical treatises for assistance in answering this question. In our own minds we do find the conviction that, in spite of all the difficulties that attend ethical decisions in particular cases, there is an infallible right and an infallible truth, that we can distinguish between "counsels of prudence and sagacity" and the absolute command of the moral law.

Still there is a connection which Kant refused to recognise, so completely did he abhor the emotional side of human nature, between the moral law and the emotions and which in no way detracts from the worth of the Rationalistic hypothesis.

Moral judgments, though they may proceed from Reason, are not necessarily at war with the emotions. Common sense revolts from the extreme statement that actions are stripped of all moral value so soon as they are done from natural inclinations. Price in his *Review of the Chief Questions and Difficulties of Morals* maintained this extreme view, and its adoption by the sterner Rationalists is answerable for much of the support given to the Emotionalist argument. Personal emotions should no doubt be subordinated to the dictates of Reason, but the absence of these in a condition of pure disinterestedness need not be insisted upon as the sole determinant of moral worth. Because we are prompted by love for our neighbour as well as by a sense of duty towards him, our neighbourly actions are not less moral. Love glorifies duty; it is not as Kant declares a mere consequence of it. Moreover in the modern world especially, our contact with our fellow-creatures is so close and the appeal to the emotions everywhere so pressing that the man who can insulate himself from all emotional and social influences may by that very process of insulation deprive himself of the knowledge of the facts concerning which he must act. Capacity for feeling has not got to be exterminated; Reason's business is not to eradicate feeling but to control it. Without feelings, there could, in no true sense of the word, be experience, and the rational Rationalistic argument does not maintain as Kant's doctrine of the Categorical Imperative is sometimes interpreted to maintain that Reason is capable of arriving at moral judgments without any regard to experience whatever. Such an interpretation would involve a conception of a hard-and-fast morality as destructive in its consequences as the pure emotional conception.

COURSE OF READING

Logic.—The elementary principles of deductive and inductive logic cannot be found treated more simply and in a more scholarly manner than in Jevons' *Elementary Lessons in Logic*, in the same author's handbook in the science primers published by Macmillan, or in *Principles of Logic* by Stanley Williams (Jack). The student may also care to acquaint himself with the different views concerning the subject matter of logic, as to whether it treats of language, or of the thoughts behind the language, or of the things to which the thoughts apply. In support of the first view, the introduction to Whateley's *Logic* may be read, while the student may go to Sir William Hamilton's *Lectures on Logic* (Lecture I) for the second view, and should also read that part of Mill's *Examination of Sir William Hamilton's Philosophy* wherein this view is discussed, and the third view which is Mill's brought forward.

In the study of Terms, the simplest part of the threefold division of logic, Mill's chapter on Names in his *System of Logic* should be read, and Watt's *Logic* (Chapter IV) has a very careful analysis of ambiguous words, their classes and causes. Mill's doctrine of Connotation should also be studied in his *System*, as well as Hamilton's Lecture (VIII) on the Extension and Intension of Terms. For some insight into the processes which shape language and affect the intension and extension of terms, Mill's chapter on *The History of the Variations in the Meanings of Terms* should be read, while all philological reading will deepen the student's appreciation of the significance of the words he uses. Bain's *Logic* should also be referred to for the rules of Definition and Classification.

Coming to the great question of the nature and import of propositions or the theory of the predicables, the student should read Mill, Chapters V and VI, Sir W. Hamilton's Lectures, VIII and XIII, and also refer to Mill's *Examination of Hamilton*, but he is warned that the discussion is a metaphysical one and that in consequence he would do well to defer reading on this point until later.

Hamilton's Lectures, V and VI, on the Laws of Thought, should be read, but the average student will find the ordinary text-book treatment sufficient for his purposes, and the same advice applies to reading on the subject of the moods and figures of the syllogism.

De Morgan's *Formal Logic* is recommended particularly for the chapter on Fallacies; if the student wishes for some entertaining specimens of the fallacy of *Ignoratio Elenchi* he will find them in Sydney Smith's famous *Noodle's Oration*.

Hamilton's Lecture XIII and Mansel's *Aldrich* will assist the study of hypothetical and disjunctive syllogisms.

After Jevons the student should read Fowler's *Inductive and Deductive Logic*, which is more difficult than Jevons', and Keynes' *Formal Logic*, still more advanced. Venn's *Empirical Logic*, a treatise on the logic of chance, and Boole's work on the algebraic treatment of logic, are recommended to the advanced student. Through these books the student will become acquainted with important variations in the exposition of logical problems which the simple manual cannot present. The Port Royal *Logic*, Baynes' translation, ought to be studied, especially on Method. Baynes' own book should be read for a clear exposition of the doctrine known as the Quantification of the Predicate, though Jevons gives a good account of it in his *Elementary Lessons*.

For a sketch of the origin and scope of logic, the reader will find an easy and popular survey in the introduction to Minto's *Logic*. An interesting account is there given of the circumstances from which the Aristotelian logic sprang, of the prevailing enthusiasm for dialectic disputation, of the need then felt and responded to, for the invention of an accurate instrument for pursuing this intellectual pastime. The main lines of the Socratic methods and the principles of what have ever since constituted coherence in an argument are graphically indicated.

A knowledge of those circumstances which above all required consistence from the syllogism, is indispensable to the realisation of the genesis of inductive logic which, after the mediæval logic which was still concerned with detecting inconsistencies rather than untruth in dogmatic arguments, sprang from the need of an instrument to discover truth by empirical methods.

The introduction to the inductive section of Minto's *Logic* admirably summarises the rise of the inductive method, of the history of which the student, in coming to inductive logic, ought to know something. Lord Bacon is commonly supposed to be its founder, as he indeed claimed to be, in calling his great work the *Novum Organum*, but long before Bacon's time there had been men who asserted his aims. And in so far as the *Novum Organum* declared that no new knowledge was to be won by the syllogism, which was only useful as a controversial or demonstrative instrument, and that to get fresh knowledge logical method must reverse itself and proceed from particular facts instead of from theoretical data, it was but advancing an argument which many eminent men before Bacon had advanced. Whewell's *History of the Inductive Sciences* gives a wide survey of these earlier pioneers, of whom Roger Bacon, a Franciscan friar of the thirteenth century, is recognised as the chief. It was Roger Bacon who declared that of the two modes of knowing, argument and experience, only experience could give certain knowledge, and that Aristotle had better be burned if he were going to be accepted without inquiry.

But Lord Bacon was the first to insist upon the necessity of a definite method of investigation, an *ars inveniendi*, for the discovery of the new knowledge. Observation and experiment had been asserted as necessary before, particularly by the great Franciscan, by Gilbert, by Copernicus, Galileo, and many others whose names can be read in Whewell, but a definite method had never been laid down. Bacon went beyond these men in his *Novum Organum*, when he undertook to furnish a complete instrument by means of which man should be able to arrive at the secrets of nature.

All the "idols," or perversions of experience, must, he declared, be abolished; the mind must bring an unbiassed judgment to bear upon facts. Science must turn away from the fruitless discussion of conceptions to the things themselves in order to acquire that lasting knowledge which is power. Man can only dominate the world by knowing the world. The student cannot do better than read at least the opening paragraphs of the *Novum Organum* (Fowler's edition), as the principles which these instil have been the principles of all scientific discovery.

To the defects of the Baconian method Mill directed much criticism in the third book of his system, the points of which criticism are well brought out in Chapter XXX of Jevons' *Elementary Lessons*. Minto also supplies a useful criticism of Bacon's undue stress upon the sufficiency of induction for an instrument to knowledge, and treats of the relation of Mill's *System of Logic* both to the Aristotelian logic and to contemporary logicians and scientists. No study of Mill is complete without a

study of his great contemporaries, Herschel, Whewell, Hamilton, and Whateley. Herschel's *Discourse on the Study of Natural Philosophy* should be read. The student ought to read the whole of Mill's third book. In regard to his chapter therein, "On induction improperly so-called," it should be remembered that there is considerable disagreement between Mill's views and the views of other logicians.

Hamilton's Lecture XVII and the Appendix on Induction and Example are also valuable.

For those students who are prepared to plunge at once into the study of the intimate relationship between metaphysics and logic, Windelband's *History of Philosophy*, particularly that section of it dealing with the systematic period of Greek philosophy, will be found a useful guide. But the average student is advised to defer this stage of his approach to logic until he is fairly well acquainted with the other branches of philosophy, at any rate with metaphysics.

Metaphysics.—No better introduction to the study of philosophy, and to those profound metaphysical problems which lie at the foundation of knowledge, could be found than Mr. Bertrand Russell's *Problems of Philosophy* in the Home University Library. After reading that little book, the student will have a clear view of the issue between materialism and idealism, and may with advantage turn to study the aspects of it in the writings of those philosophers who have markedly determined the course of its development.

Modern philosophy, as has been said, begins with Descartes, and in Descartes' *Meditations*, which can be read in Haldane and Ross's excellent translation, the philosopher traces his mental progress from the wide scepticism with which he began his reflections to the famous "Cogito, ergo sum," and to the consequent implications of that conclusion in the theory of innate ideas.

Descartes, in Blackwood's series, by J. P. Mahaffy, is also recommended, while Professor Caird's essay in the tenth edition of the *Encyclopædia Britannica*, on Cartesianism, gives a comprehensive view of Cartesian philosophy and of its relation to the other currents of the philosophical thought of the time. But this essay is perhaps too advanced for the beginner.

From Descartes the student should, at first, proceed to Berkeley's *Dialogues between Hylas and Philonus*, which constitute the first consistently developed presentment of the idealistic standpoint and show an extraordinary dexterity of argument. Again the student should refer to the Blackwood series of philosophical classics for Professor Fraser's *Berkeley*, and may also read the same author's memoir of Berkeley which is prefaced to his edition of Berkeley's works. Of those works, besides the Dialogues above re[illegible] to, the *Treatise on Human Nature* is [illegible]ps for the beginner the most interesting.

Locke's *Essay on the Human Understanding* and Fraser's monograph on *Locke* (Blackwood's series) are also advised before going on to Hume, whose *Enquiry concerning Human Understanding*, advancing from Locke's sensationalism in a new direction, brought the idealism of Berkeley to a standstill and plunged eighteenth-century thought into a profound scepticism from which Kant, on the one hand, and the Scottish school of philosophy on the other, revived it.

Kant's works are difficult to read, though the *Prolegomena to every future metaphysic* should be attempted. A clear summary of Kant's great system and an able criticism are given in *Kant* by A. D. Lindsay in the People's Books; Professor Wallace's monograph on *Kant* and Caird's *Philosophy of Kant* are also recommended.

More advanced treatment of Kantian philosophy is found in Adamson's *Lectures on the Development of Modern Philosophy*, and these lectures also contain advanced treatment of Descartes, Locke, Leibnitz and other pre-Kantian philosophers.

An excellent comparative survey of Kant's doctrines and those of Reid, the great Scottish philosopher and founder of the common-sense school, is given in Seth's *Scottish Philosophy*, whose chapters on Descartes and Locke, and the scepticism of David Hume, are admirably pointed and supply a clear view of the ground from which Reid started. The chapter in the same book on the relativity of knowledge is so brilliant in its lucidity and literary form that it might even be read by the student immediately after reading Mr. Bertrand Russell's text-book first quoted.

Professor Seth's lectures on Hegelianism are extremely stimulating and comprehensive of all that the Hegelian theory embodies, especially from a religious standpoint. The two volumes on *Hegel* and *Fichte* in the Blackwood series by Fraser and Adamson respectively are also recommended. Caird's *Introduction to the Philosophy of Religion* and F. H. Bradley's *Appearance and Reality* should also be read; they are in sympathy with the idealistic Hegelian interpretation of Kantian principles.

Though the student is advised to confine his studies at the outset to modern philosophy, he should afterwards acquaint himself with the outlines of the beginning of metaphysical thought in early Greek philosophy. There are many histories of philosophy in which these outlines can be studied. A. W. Benn's *The Greek Philosophers* gives full, clear treatment, and Burnet's *Early Greek Philosophy* is also useful, while for an essentially individual presentation of the platonic idealism, Walter Pater's

Plato and Platonism may be read in conjunction with Plato's *Republic* and the *Dialogues*.

The chapter on "Conceptions of Being in the Cosmological Period of Greek Thought," in Windelband's *History of Philosophy*, translated by J. H. Tufts, handles the historical development of early metaphysics in an original and interesting way. Indeed Windelband's History may be recommended as a work of general reference to the student who wishes to view the interrelationship of the different branches of philosophy from the standpoint of the whole science. Ueberweg's History is another reliable work of reference, and so is Baldwin's *Dictionary of Philosophy*.

Psychology.—The student should begin his study of psychology with either *Psychology* by Watt (People's Books), William James' *Principles of Psychology* or his smaller text-book, or Titchener's *Text-book of Psychology* or his shorter *Outline*, and with regard to the James' book, the student is advised to follow the author's directions in the preface as to the omission, on first reading, of certain chapters.

The physiological presuppositions of any of these books may, as Professor James himself says, be studied in any standard text-book of anatomy or physiology, citing H. N. Martin's *Human Body* and G. T. Ladd's *Physiology* in particular.

An extremely informing little text-book on *Physiological Psychology* has been recently published in the Temple Primers by Professor McDougall, whose book *Psychology* is also recommended, as well as the same author's book *Body and Mind*. The introduction to this text-book gives an admirable presentment of the hypothesis underlying modern experimental methods, and the sketch of the nervous system and its functions which is the subject of the first chapter should enable the student to skip, at first, the detailed exposition of the functions of the brain and some general conditions of brain activity to which James' opening chapters are directed, and to start with his extraordinarily illuminating chapter on Habit.

Wundt's *Outlines of Psychology* and Kulpe's *Psychology* should ultimately be read, but neither of these books is easy reading for the beginner, and if the student masters either James or Titchener he will be well launched into his subject. Indeed it is almost a work of supererogation to offer advice for subsequent reading, for James' references to physiological writings are so copious and his survey of the whole field so complete that the student can hardly fail of his own accord, supposing him to be interested, to go directly to some of the innumerable authorities mentioned in order to supplement and to strengthen his knowledge. Titchener's text-book, too, supplies most comprehensive bibliographical notes, amounting almost to brief historical digests of the genesis and development of the various views propounded, at the end of each chapter. The bulk of these references will, however, be found too advanced for the ordinary student.

As psychology examines all the conditions and phenomena of consciousness, it is manifestly concerned with the study of the individual consciousness in special stages other than the stage of the adult mind. W. Preyer's *The Mind of the Child* treats of one of these stages; *Adolescence*, by Stanley Hall, treats of another. J. M. Baldwin's *Mental Development in the Child and in the Race* studies these stages genetically.

Psychology also investigates the abnormal consciousness, the behaviour of people who from obvious bodily defects, or in conditions of temporary or permanent mental derangement, must be considered as deviating from the normal. Books upon criminal psychology fall under this category, as also Ribot's *Diseases of Personality*, a study of permanent mental derangement, Lombroso's *Man of Genius*, Moll's *Hypnotism*, Hart's *Abnormal Psychology*, and many of the publications of the Society for Psychical Research. In connection with abnormal psychology, the student should read the chapter under that heading in Professor McDougall's handbook *Psychology*.

Moreover, as the scope of psychology extends beyond the study of the individual human mind, whether normal or abnormal, and includes the study of the collective human mind, its results in this direction may be classed under the head of social psychology, which division is ably treated by McDougall in an *Introduction to Social Psychology*, and in the *Social Psychology* of F. A. Ross. A particular aspect of the abnormal collective or social consciousness is the subject of *La Foule Criminelle* of S. Sighelo, but this is not translated.

In addition to the study of the human consciousness, normal and abnormal, single and collective, psychology includes, as we have seen, a study of the animal consciousness. For this branch of the subject, E. Thorndike's *Animal Intelligence* and M. F. Washburn's *The Animal Mind* are recommended.

It may be of assistance to the reader to know something of the representatives of spiritualistic and materialistic psychology in the period of modern philosophy.

Descartes was the founder of the modern spiritualistic school, his spiritualism was however of a dualistic nature, and it was Leibnitz who in his *Monadology* initiated monistic spiritualism.

Hobbes was the founder of modern materialism, but the mechanical-materialists of the eighteenth century owed also much inspiration to the inconsistency of Descartes' doctrine expressed in the arbitrary distinction which he drew between the consciousness of men and of animals.

Locke and Hume were the direct progenitors of the Associational Theory first propounded comprehensively by David Hartley in his *Observations on Man*, 1749, which showed how by the constant process of association the more complex emotions were developed from elementary sensations. For a brief survey of Hartley's doctrine the student may read the pages on Hartley in Sidgwick's *Theory of Ethics*, Chapter IV.

To Hartley's work succeeded the elder Mill's *Analysis of the Phenomena of the Human Mind*, 1829, and Associationalism reached its full development in J. S. Mill's *Examination of Sir William Hamilton's Philosophy*, 1865.

The associational theory is at the basis of the realism of Alexander Bain, whose works were *The Senses and the Intellect*, 1856, *The Emotions and the Will*, 1859, and *Mental and Moral Science*, 1868, and of the *Principles of Psychology* of Herbert Spencer. Lotze and Fechner, who were the forerunners of modern experimental-psychology, built upon the spiritualism of Leibnitz.

Ethics.—The student is advised to get a general idea of the history of ethics and of its relation to metaphysical thought before embarking upon special writers' individual views of the questions at issue, either in ancient or in modern times.

For this purpose Sidgwick's *Outline of the History of Ethics* is recommended; the student will learn from this book who have been the principal figures in the development of early, mediæval, and modern ethics. He may not be tempted to refer to original authorities in the early period, and certainly not in the mediæval period, but if he should be, for the early period, some of the Plato dialogues, particularly the Gorgias, the Protagoras, and the Philebus, should be studied; also the *Republic* of Plato and Aristotle's *Nichomachean Ethics*.

Coming to the modern period and assuming that the student is desirous of first-hand knowledge, the following works embody the views of the most important moral philosophers:

Thomas Hobbes' *Leviathan*, wherein all the activities of mankind are consistently reduced to the impulse to self-preservation; also the monograph on Hobbes in the Blackwood series, by G. C. Robertson. Cudworth's *Treatise concerning Eternal and Immutable Morality*, which set up against the "selfish system" of Hobbes, the innateness of the moral order.

Locke's *Essay on the Human Understanding*, which vehemently opposed the doctrine of innate ideas but nevertheless insisted upon the fact that the moral law proceeded from a divine authority. *Locke* in the Blackwood series is recommended.

Shaftesbury's "Enquiry concerning Virtue and Merit," in the *Characteristics of Men, Manners, Opinions, and Times*, insisting upon the naturalness of the social affections and the æsthetic value of full self-development.

Butler's *Fifteen Sermons upon Human Nature*, asserting the overwhelming claims of conscience as an arbiter of moral issues; also W. L. Collin's *Butler* in the Blackwood series.

Hutcheson's *System of Moral Philosophy*, in which Shaftesbury's theory of the moral sense was developed and invested with a full æsthetic radiance.

Hartley's *Observations on Man*, the trend of which is indicated in the Course of Reading for Psychology.

Hume's *Treatise on Human Nature*, which approaches ethics from a purely psychological standpoint, and, dismissing the assumption of an innate moral sense, explains the moral judgments by referring them to an extensive sympathy; this view was further developed by Adam Smith in his *Theory of Moral Sentiments*. *Hume* by Professor Knight is recommended.

Price's *Review of the Chief Questions and Difficulties of Morals*, which returned to the intuitional standpoint, whose views, as those of Reid in his *Enquiry into the Human Mind*, bear strong affinity to the views of Kant.

Kant's *Fundamental Principles of the Metaphysic of Morals*, translated by T. K. Abbott in that author's *Kant's Theory of Ethics*. The monograph on Kant in the People's Books should be read.

For the more modern period, Mill's *Utilitarianism*, Grote's *Examination of the Utilitarian Philosophy*, Herbert Spencer's *Data of Ethics*, Henry Sidgwick's *Methods of Ethics*, T. H. Green's *Prolegomena to Ethics* are of course essential to a comprehensive survey, and, with regard to the school of evolutionary ethics, Leslie Stephen's *Science of Ethics* and Alexander's *Moral Order and Progress* should be read.

But the main points of present-day ethical discussion are brilliantly surveyed in Dr. Hastings Rashdall's little book on *Ethics* in the People's Books, and present in smaller compass the views given in his *Theory of Good and Evil*. The student cannot do better than study these books and under their guidance proceed to individual modern authors to whose writings they will introduce him.

Professor Moore, the author of the *Principia Ethica*, has also written a useful guide.

I. COOPER WILLIS.